THE ENGINEER

A Seven-Day Journal

Sir Henry Guy, Hon. M.I.Mech.E.

THE Council of the Institution of Mechanical Engineers has unanimously elected Sir Henry Guy, C.B.E., D.Sc., Wh.Ex., M.I.Mech.E., F.R.S., to honorary membership of the Institution, in recognition of his distinguished scientific and engineering attainments and his outstanding services. Sir Henry was secretary of the Institution from October, 1941, until his retirement, through ill health, early last year. He began his career as a pupil of Mr. T. Hurry Riches, chief mechanical engineer of the Taff Vale Railway, and subsequently joined the technical staff of British Westinghouse Company, Ltd., which later became the Metropolitan-Vickers Electrical Company, Ltd. Sir Henry was appointed chief engineer in that company's mechanical department in 1918. He became a graduate of the Institution of Mechanical Engineers in 1906, an associate member in 1912, and a member in 1927, and for many years was chairman of the North-Western branch. He served on the Council of the Institution from 1929 to 1941 and was elected a vice-president in 1938. Sir Henry was elected a Fellow of the Royal Society in 1936, and has served on the Society's Council, and on many of its committees. During and since the second world war Sir Henry has been a member of many important Government and industrial committees and has acted as chairman of several of them. In recognition of his work in the engineering and scientific world, he was created a Knight Bachelor in the New Year Honours of 1949. Sir Henry's many papers to the Institution of Mechanical Engineers and other learned societies have included one on "The Economic Value of Increased Steam Pressure," for which he was awarded the Thomas Hawksley Gold Medal in 1927. In 1939 Sir Henry was invited by the Royal Society and the Institution of Civil Engineers to give the fourth Parsons Memorial Lecture, for which he received the Parsons Memorial Medal.

The BEAMA Dinner

THERE was a large company present at the dinner of the British Electrical and Allied Manufacturers' Association—the first since 1938—which was held at Grosvenor House, London, on Thursday evening of last week. Sir George Nelson, president of the Association, was in the chair. In proposing the toast "The Electrical Industry," Professor E. N. da C. Andrade, F.R.S., referred to the vast field of activity covered by the industry, which, he said, demanded a far-seeing organisation, nourished with knowledge and led with vision, with an intimate knowledge of the industry's circumstances and an infinite faith in its future. Such an organisation, Professor Andrade continued, was to be found in BEAMA. In mentioning some of its activities, Professor Andrade spoke of the foundation of the Chair of Electrical Engineering at Cambridge, and of the Association's enthusiasm for research and education in general. The research carried on within the electrical industry to-day, he said, was impressive and well justified the very considerable sums that were spent on it. Acknowledging the toast, the president, Sir George Nelson, referred to the cavalcade of remarkable scientific discovery and engineering achievement which was revealed when the progress throughout the world, since the time of Faraday, was examined. To-day, Sir George said, the electrical industry was spending very large sums on research. It recognised that the generation of power from sources other than coal and oil must be advanced with all speed. About the materials necessary to increase production, Sir George urged that steel output must be increased to meet the needs of the future, and claimed that shortage of scrap could not be accepted as a continuing cause of limited supplies. He believed that the most efficient size for blast-furnaces had been determined. There should be more furnaces of that size, Sir George suggested, and the smaller and less efficient sizes should be replaced as soon as possible so that an extra supply of pig iron became available to make up for deficiency in scrap. Mr. T. F. Lister, chairman of the BEAMA council, proposed the toast of "Our Guests," to which response was made by Lord Radcliffe of Werneth, P.C. The final toast, which was warmly accorded, was that of "Our President," proposed by Sir Harry Railing, vice-president.

Institute of Metals' Essay Competition

THE Institute of Metals has announced an annual essay prize competition for student members and all associate members of local sections who are eligible for student membership of the Institute, provided they are within the normal student membership age limits, namely, seventeen to twenty-five. For this year's competition candidates may select a subject which comes under either of the two headings, "Non-Ferrous Foundry Practice" and "Metallography in Industry." One prize will be awarded under each of those headings. The essays, which must be submitted in English, should be from 2500 to 3500 words in length, and must not exceed 3500 words. They must be typewritten, with double-line spacing. The subject matter should be logically presented and should have a metallurgical content to impress the adjudicators by soundness, exercise of critical faculty, and originality of approach. The two prizes for the best essays will be twenty guineas each. Each prize will take the form of ten guineas in money and ten guineas in scientific, technical or other appropriate books selected by the prizewinner. If it is considered to be of sufficient merit, a prize-winning essay may be published in the Institute's *Bulletin* or selected for reading before a local section. Essays must be submitted to the Secretary, the Institute of Metals, 4, Grosvenor Gardens, London, S.W.1, not later than May 19, 1952, and must be accompanied by a certificate, signed by the entrant, that the essay is entirely his or her own work and that it has not been submitted for any other competition.

Economic Sizes and Groupings of Generating Plant

CONSIDERATIONS influencing the choice of the sizes and groupings of power station boilers and turbines were discussed in a paper "Economic Plant Sizes and Boiler Groupings on the British Grid," presented before the Institution of Electrical Engineers by Messrs. Brian Donkin and P. H. Margen, on Wednesday, January 30th. The paper is based on the fact that economy in capital cost and working costs per kilowatt favours the adoption of larger plant units in power stations, whereas the need for reserve capacity and stronger electrical connections impose limits on the size. Methods are developed in the paper for determining the optimum sizes and groupings of plant units, with particular reference to the conditions under which the British grid operates. The authors' conclusions may be summarised as follows:—Trends of development in plant design, load growth, siting of stations, and nature of distribution and transmission networks all tend to increase the economic plan sizes on the grid and to simplify the economic plant groupings. For plant designed during the next few years few regions or conditions on the grid appear to call for unit sizes of less than 100MW. A large fraction of these units would have to be capable of performing shift operations at a later stage of their life so that designs giving the necessary flexibility would have to be developed. Published results suggest that considerable progress has already been made in that direction in the United States. One boiler per turbo-alternator of equal capacity with a simple type of steam tie bar appears to be the most favourable grouping for most conditions. In stations using reheat cycles, cross-connections are expensive and should generally be omitted. The use of large units on sites of restricted total capacity might result in stations having only two generation units. This is economically sound. Single-unit stations should generally be avoided because they lack the advantages of steam cross-connection for the co-ordination of boiler and turbo-alternator overhauls. Certain pithead sites of very limited capacity may prove exceptions to this rule. Conclusions on future economic plant sizes and groupings, once reached, would guide development work and construction programmes for many years, so that it is particularly important to investigate this problem in the light of all experience available. In this connection, the authors feel that it would be of great value if plant designers and users were to publish additional data and views on capital outlay/size relations and on the starting and load-changing performances of large plant units.

The Colombo Plan Exhibition

AN international exhibition will be opened in Victoria Park, Colombo, Ceylon, on February 16th, the object of which is to publicise and illustrate the purpose of the Colombo Plan. It may be recalled that the Colombo Plan involves a programme of expenditure of the order of £1868 million over the next five years in the development of various countries, most of which are members of the Commonwealth, of South-Eastern Asia, lying between the Persian Gulf and the Philippines. Capital aid is to be given under the plan by countries such as the United Kingdom, Canada and Australia. The proposals of the plan for the first five years include the cultivation of an additional 13 million acres of land (an increase of 3½ per cent), the provision of irrigation for a further 13 million acres (an increase of 17 per cent), and an increase of 1·1 million kW in electrical generating capacity (an increase of 67 per cent). It is expected that an increase of 6 million tons in the annual production of food grains will result from this programme, and whilst it has been pointed out that the programme will do little more than hold the present position, a sound foundation for further development will have been laid. The developments of the plan are based mainly on engineering works, and the exhibition will reflect this fact. Nearly fifty British engineering firms will be exhibiting in the U.K. pavilion, whilst others are exhibiting in the Trade and Commerce Section. The Association of Consulting Engineers will be amongst the exhibitors; it has prepared a book for the exhibition containing a selection of about thirty technical articles, written by member firms, which nearly all describe work carried out in South-Eastern Asia, Africa and Australia under the direction of firms of British consulting engineers belonging to the Association.

DAMS AND POWER STATIONS OF THE CENTRAL VALLEY PROJECT, CALIFORNIA

FIG. 3—SHASTA POWER STATION

FIG. 5—KESWICK DAM, RESERVOIR AND POWER STATION

FIG. 2—SHASTA DAM, RESERVOIR AND POWER STATION

FIG. 4—FRIANT DAM, RESERVOIR AND FRIANT-KERN CANAL

The Central Valley Project, California

No. II—*(Concluded from page 124, January 25th)*

The initial phase of the Central Valley project in California went into firm operation at the beginning of August, 1951. This development of the U.S. Bureau of Reclamation has cost an estimated 400,000,000 dollars. It consists of an integrated system of dams, power and pumping plants and canals. Major objective is to equalise the water resources of the central basin of California by storing water at its northern end and transporting it to and from lands 500 miles to the south. The development is described.

Shasta Dam and Reservoir

MOUNT Shasta lies at the head of the Central Valley, and Shasta dam, situated at its foothills, controls the waters of the Sacramento, McCloud and Pit Rivers. The reservoir formed by Shasta dam is known as Shasta Lake, and is the largest artificial lake in California. It has a storage capacity of 4,493,000 acre-feet, a surface area of 29,500 acres, a surface elevation at high water of 1065ft, and a depth of water at the dam of 515ft. Shasta dam is the second highest and second largest concrete gravity dam in the world. It has a structural height of 602ft, a hydraulic height of 487ft, and a base width, including apron of 780ft. It is of variable arch design, the 375ft long straight central spillway being flanked by slightly curved wings having a radius of curvature to the dam axis of 2500ft. The dam crest is 30ft wide, 3460ft long and carries a roadway at 1077·5ft elevation. The construction of the dam required 6,541,000 cubic yards of concrete and was completed in 1945. The spillway has a crest elevation of 1037ft and a maximum capacity of 200,000 cusecs. It has an ogee weir and is controlled by three dam gates, each 110ft by 28ft. The outlet works consist of eighteen 102in diameter outlet conduits through the spillway section, controlled respectively by fourteen outlet gates and four valves. There are five penstocks leading to the power station, which are controlled by five 15ft by 19ft coaster gates.

Shasta power station (Figs. 2 and 3) is at the foot of the spillway and, in plan, is inclined at approximately 45 deg. to the spillway flow. Its generating capacity of 379MW is produced by five 75MW main generator units and two 2MW station service units. The station operates with an average head of 375ft and the maximum head is 475ft. The main Francis turbines are rated 103,000 h.p. at 138·5 r.p.m. and are direct connected to 13·8kV generators.

Friant Dam and Reservoir

Friant dam (Fig. 4), the second major multiple-purpose structure of the Central Valley project, is on the San Joaquin River, 20 miles north-east of Fresno. It has a structural height of 319ft, a hydraulic height of 270ft and a base width, including apron, of 487ft. The dam crest is 20ft wide and 3488ft long, the roadway elevation being 582ft. The construction of this concrete gravity dam required 2,135,000 cubic yards of concrete and was completed in 1942. The spillway has a crest elevation of 560ft and a maximum capacity of 92,000 cusecs. It has an ogee weir and is controlled by three 100ft by 18ft drum gates. The reservoir formed by Friant dam is known as Millerton Lake and has a storage capacity of 521,000 acre-feet. It has a surface area of 4900 acres, a surface elevation at high water of 578ft and a length of about 15 miles. Water may be released from Friant dam in three directions, and hence there are three separate outlet works. Each of the outlets to the San Joaquin River and the Friant-Kern canal consists of four 110in diameter pipes which are controlled by four 96in regulating valves. The outlet to the Madera canal consists of two 91in diameter pipes, controlled by two 86in needle valves. Friant dam is not being used to generate hydro-electric power, as the canals receive most of the water at a high elevation of the dam in order to ensure its flow by gravity along the various irrigation works.

Keswick Dam and Reservoir

Keswick dam (Fig. 5) is on the Sacramento River, 9 miles downstream from Shasta dam. It forms a reservoir having a surface area of 640 acres and a capacity of 24,000 acre-feet. The dam is a concrete gravity structure, which was completed in 1950 and contains a volume of 197,000 cubic yards of concrete. Its structural height is 159ft, its hydraulic height 118ft and its base width, including apron, is 260ft. The crest of the dam is 20ft wide, 1046ft long and carries a roadway at 595·5ft elevation. The spillway has a crest elevation of 537ft and a maximum capacity of 200,000 cusecs. It has an ogee weir and is controlled by four 50ft by 50ft regulating gates. The outlet works consist of one 60in diameter outlet pipe for the fish-trap works and three penstocks, which are controlled by three 12ft 7in by 23ft 5in fixed-wheel gates. The dam has been equipped with fish elevators, which trap the salmon and sea trout of the Sacramento River before they reach Shasta dam. The fish are transported in special lorries to hatcheries and spawning grounds on streams tributary to the Sacramento River below Keswick dam.

The Keswick power station is situated immediately adjacent to, and in line with, the spillway. Its generating capacity of 75MW is produced by three 25MW generator units.

The Canal System

The entire canal system (Figs. 7–10) of the initial phase of the Central Valley system was constructed with the aid of such excavating trimming and concrete lining machines, as are shown in the illustration of the Delta-Mendota canal (Fig. 7), which runs from the Tracy pumping station to the Mendota Pool. This particular trapezoidal canal section has a width at the top of 100ft, a width at the bottom of 45ft and a depth of 18ft. It has a capacity of 4600 cusecs and a length of 120 miles. The Madera Canal has a capacity of 1000 cusecs and a length of 37 miles, running from Friant dam to Ash Slough. The Friant-Kern canal has a capacity of 5000 cusecs and a length of 153 miles and runs from Friant dam to the Kern River, near Bakersfield. The Contra Costa canal runs from the delta to the town of Martinez, near the valley outlet into the San Francisco Bay. It has a capacity of 350 cusecs and a length of 48 miles. The following lifts are applied to the waters of the Contra Costa canal, travelling toward the ocean :—

No. 1 pumping plant	22·24ft
No. 2 pumping plant	23·60ft
No. 3 pumping plant	31·96ft
No. 4 pumping plant	48·93ft
Clayton pumping plant	39·00ft
Ygnacio pumping plant	85·00ft

The Delta Cross Channel runs from Walnut Grove on the Sacramento River to the Tracy pumping plant and the Contra Costa canal intake works. It has a capacity of 7600 cusecs and a total length of 50 miles, made up of 49 miles of natural channels used and 1 mile of excavated channel. In Fig. 10 we show the excavated channel, the two 30ft by 60ft radial gates and the control structure on the Sacramento River, which have been constructed at Walnut Grove.

The Tracy Pumping Plant

The Tracy pumping plant (Fig. 6) is the main pumping station of the Central Valley project. The accompanying illustration shows the completed station, which is situated at the end of a 2-mile long canal connecting it to the Sacramento-San Joaquin River delta. The station installation comprises six 84in vertical-shaft, centrifugal pumps, having a combined capacity of 4600 cusecs at the design lifting head of 197ft. The pumps, which were manufactured by the Worthington Pump and Machinery Corporation, of Harrison, New Jersey, are "Y"-connected, in pairs, to three discharge pipes of 15ft inside diameter. The pump rotors are each direct-connected to the rotors of six vertical-shaft, 1·3kV, three-phase, 60 c/s a.c. synchronous motors. The motors rotate at 180 r.p.m. and each have a capacity of 22·500 h.p. They were manu-

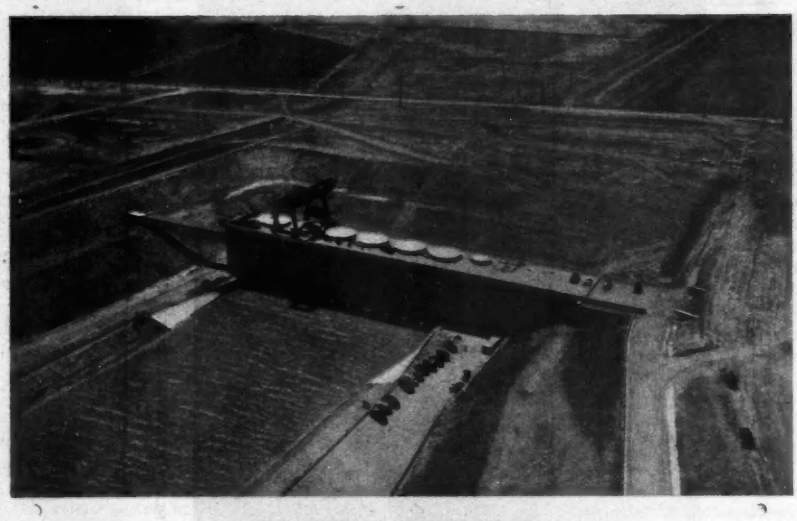


Fig. 6—Tracy Pumping Plant

CANAL SYSTEMS OF THE CENTRAL VALLEY PROJECT, CALIFORNIA

FIG. 6—FRIANT-KERN CANAL

FIG. 10—DELTA CROSS CHANNEL EXCAVATION JOINING THE SACRAMENTO RIVER

FIG. 7—DELTA - MENDOTA CANAL

FIG. 9—CONTRA COSTA CANAL INTAKE WORKS

factured by the Allis Chalmers Manufacturing Company, of Milwaukee, Wisconsin. Power for the operation of the Tracy pumping plant is obtained from the Shasta and Keswick power station through a 230kV transmission line, which extends along the east side of the Sacramento Valley.

Folsom Dam

The U.S. Army Corps of Engineers is responsible for the construction of the Folsom dam, which has now been authorised by Congress as an additional part of the Central Valley project. The dam will be situated on the American River at Folsom, about 20 miles east of the city of Sacramento. On September 17, 1951, a 29,444,000 dollar contract for the construction of Folsom dam was awarded to the Merritt-Chapman and Scott Corporation, of New York, and the Savin Construction Corporation, of Hartford, Connecticut. Folsom dam, which is part of an overall project for the development of the American River basin area, will provide flood control protection as well as irrigation and power. Excavation for the power station is now proceeding under a separate contract. The main concrete section of the dam will be 1400ft long, with wing embankments of rock and earth extending its overall length to more than two miles. Approximately 340ft high, the dam will provide storage capacity for about 1,000,000 acre-feet of water. Eight gates will control the flow over the spillway section and three 15ft 6in diameter penstocks will feed water to the power plant. The construction of the dam is estimated to require approximately 9,609,000 cubic yards of excavation, 1,108,470 cubic yards of concrete and 8,834,000 cubic yards of earth and rock fill for the wing dykes. The U.S. Bureau of Reclamation is responsible for the construction of the Folsom power station, which will have a capacity of 162MW, made up by three 54MW generators. The first unit of this plant is expected to be ready for operation in July, 1954.

Future Developments

Among the more immediate future developments in the Central Valley basin, the Sacramento River system of canals to bring water on to the rich farm lands of the Sacramento Valley became a part of the project through legislation signed by the President in September, 1950. When this unit is completed 200,000 acres in Tehama, Glenn, Butte and Colusa Counties will be brought into the project service area. Both the east and west sides of the Sacramento Valley will be served by three main canals in this system. The Chico Canal will extend 19 miles from a pumping plant on the Sacramento River, south to the Chico area. The Tehama Canal and the Tehama–Colusa Canal will originate at a diversion dam on the Sacramento River downstream from Red Bluff. The Tehama Canal, with the aid of a 55ft pumping lift, will carry 500 cusecs along the western foothills to supply water to the higher lands of Tehama Country. The largest and longest of the three, the Tehama–Colusa Canal, will extend 120 miles south from the diversion dam into Colusa County and will have an initial capacity of 12,000 cusecs. About 10,000 cusecs will be diverted from the canal 5 miles below the intake to develop 24MW of electrical energy at the Mooney Island power station. This station will supply the necessary electric energy to operate the pumping plants of the Chico and Tehama Canals.

As a final link in a transmission system which will connect two great regions of the West, it is proposed to construct a 119-mile, 230kV transmission line joining the power systems of the Bonneville Power Administration and the Central Valley project. This connection has been recommended for immediate construction by the Defence Power Administration of the United States and will bring substantial gains in available power without the construction of new generating facilities. The operation of such an interconnection will bring to California excess power generated at high-water off-peak periods by the Bonneville system. On the other hand, during low-water, peak-load periods in the Pacific North-West, steam-generated power in excess of California's demand could be transferred north.

Because of the fluctuations in stream flow and irrigation releases, the output of the Central Valley hydro-electric power stations is bound to vary. A steam power station of 330MW capacity has therefore been planned to deliver energy from the delta during the periods of fluctuations and thus produce a steady flow of power for the Central Valley project. The station is intended to be situated in the Sacramento–San Joaquin delta area.

Ship Research

By S. LIVINGSTON SMITH, C.B.E., D.Sc.(Eng.), M.I.Mech.E.*

No. II—(*Continued from page 135, January 25th*)

In this Thomas Lowe Gray Lecture presented before the Institution of Mechanical Engineers, on January 18th, which we here abstract, the author grouped the various branches of research under four main headings: ship structures, hydrodynamics, ship performance and ship machinery, respectively. He selected for reference the more important and interesting examples of research under each heading.

Structural Materials.—As you can well imagine, many different materials find application in a ship; all kinds of metal, timber, plastic, and so on. But the main material used in hull construction is, of course, mild steel, and there is a strong probability that light alloys will be increasingly used in the near future. It is interesting that a material so well known and so widely used in all branches of engineering as mild steel should display an unexpected behaviour in shipbuilding, owing to the property known as notch-brittleness. If notched specimens of mild steel are broken at various temperatures it is found generally that below a certain temperature the fractures are almost entirely crystalline (brittle) with low energy absorption, and above another temperature they are entirely fibrous (ductile), with high energy absorption. The range between these two temperatures is known as the "transition range," and it varies considerably between different steels, and even between steels of similar compositions. The transition range depends also upon the kind of test by which it is determined.

The appearance of this phenomenon in shipbuilding coincided roughly with the introduction of welding on a large scale in ship construction, and a considerable amount of research on it has been carried out and is still in progress in Great Britain, in the United States, and on the Continent. The full-scale investigation on ships' structures that I have just mentioned revealed the important role played by notch-brittleness in the behaviour of steel in ships' hulls. It was found that the steel involved in the casualties was notch-brittle at the temperatures at which the fractures occurred, and this led to a great deal of research into the mechanical and metallurgical factors controlling notch-brittleness. It also became necessary to find means of assessing the property, which is not revealed by the normal specification tests. This problem is much more complex and difficult than I have time to explain, and I will only say that the research is being very actively pursued in collaboration by the many interests concerned, and considerable progress is being made. Very little trouble has been experienced with British shipbuilding steel on this score, but until the phenomenon is fully understood the margin of safety is unknown. An excellent introduction to the problem is afforded by the report of a conference held at Cambridge in October, 1945 (B.I.S.R.A., 1945), and a report by the Admiralty Ship Welding Committee (1948, Report R3).

Considerable research is also being carried out by the Admiralty into the steels used in warship construction, with special reference to notch-toughness and to their behaviour under very high rates of loading, such as are produced by explosions and at temperatures possibly lower than those to which ships are normally subjected. A programme of welding development is also in hand, again with special reference to the needs of warship construction and to the ability of the welded joints to withstand explosive loading.

Light Alloys.—The use of light alloys in ships offers attractive possibilities. The medium-strength alloys, the mechanical properties of which can be increased by cold working and which contain 3½–5 per cent of magnesium, have ultimate tensile strengths of about 14–20 tons per square inch, and possess high resistance to corrosion. These materials have already found application in the construction of deckhouses, wheel-houses, &c., and their application to more extensive superstructures is often advocated. Until it is possible to weld this material satisfactorily, which may not be very long, in view of recent developments, riveting must be adopted, and much experimental work is being done to determine the optimum diameter and spacing of rivets in this material. Many difficulties in the use of light alloys remain to be investigated, notably the effect of differential expansion between steel and light alloy arising from temperature changes and the effect on the structural characteristics of still higher temperatures arising from fires. These and other similar problems are being investigated by the Aluminium Development Association (Muckle, 1945–46 and 1948–49), including the effects on composite structures (steel and aluminium) of temperature changes (Corlett, 1950).

Welding.—The introduction of welding in ship construction represents a major change whose importance may perhaps be regarded as comparable to the change from iron to steel in shipbuilding. It has made possible improved production techniques, but has created certain new structural problems which are being investigated by the appropriate organisations. I have already mentioned some of these problems.

The welding industry in Great Britain has formed its own research organisation—the

* Director of Research, British Shipbuilding Research Association.

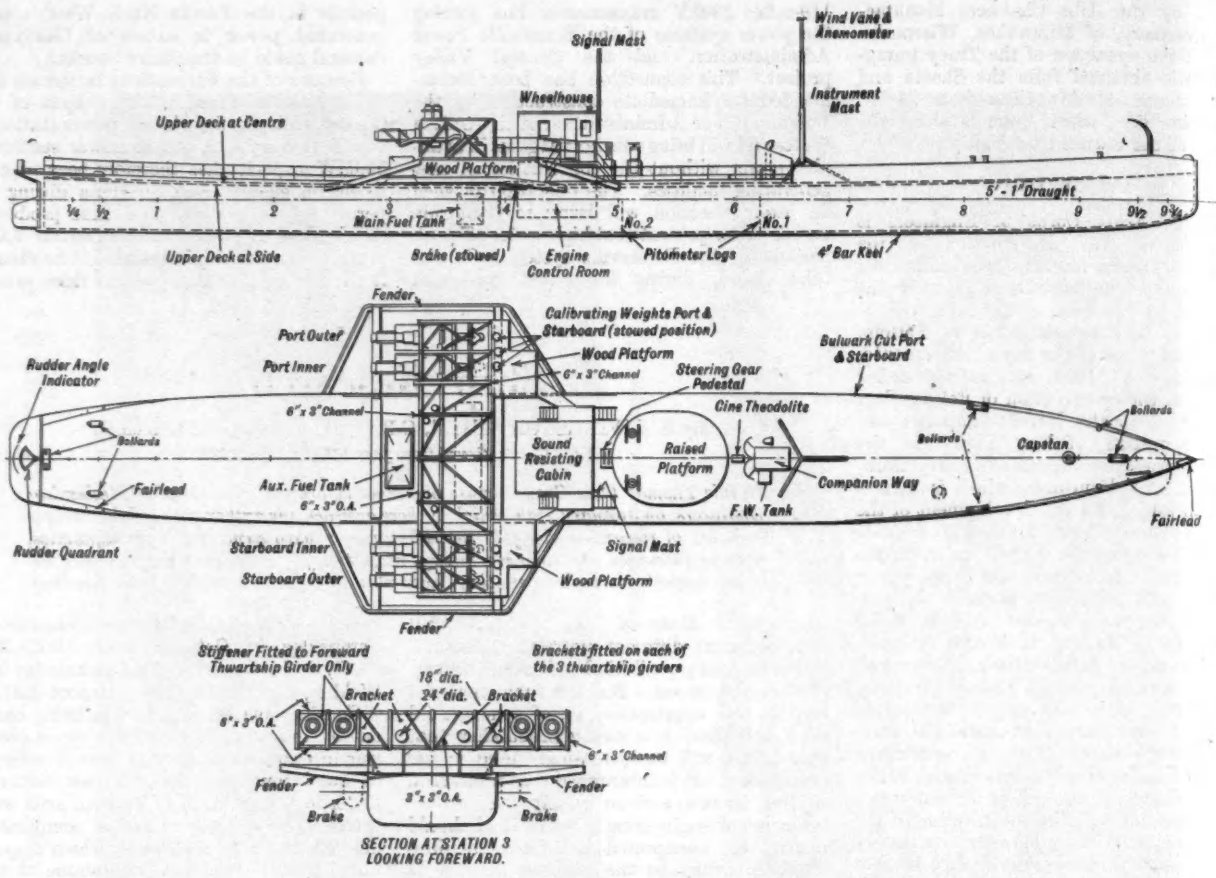


FIG. 5—*General Arrangement of Machinery Installation in the "Lucy Ashton"*

British Welding Research Association (B.W.R.A.)—which has on its programme several items of special interest to the shipbuilding industry. Among these I may mention the effects of flame cutting on the quality of welds, the welding of high-tensile or other high-quality steels and of light alloys, and the effect of fatigue on welded joints.

Another problem which has been studied by the B.W.R.A. is that of the all-welded pipe-line. The replacement of flanged, bolted joints by welds offers a number of important advantages in addition to the saving of metal, but introduces certain new problems with high-pressure, high-temperature pipe-lines. The work of B.W.R.A. has yielded much valuable information on the design of such pipe-lines.

In addition to the work of B.W.R.A., efforts to improve the quality of welds have been and are being made by all shipbuilders, both individually and collectively. It has been found that the welding operators must be well and thoroughly trained, and that tests of the quality of their work, either by X-rays or other means, have a very good effect on their skill and efficiency. Moreover, almost every shipbuilder who uses welding in ship construction carries out research on welding sequences as applied to prefabrication problems. Many of the results obtained from this work are never published, but occasional notes appear in welding and shipbuilding journals.

Vibration.—Marked vibration in ships is to be avoided at all costs. Only in rare cases do the resultant stresses reach significant magnitudes, but considerations of comfort and nuisance make vibration most undesirable.

The designer's problem is to determine the critical hull frequencies in the design stage when decisions are being made regarding the choice of propeller speed, number of blades, &c. Great efforts have therefore been made to improve the available methods of estimating ship vibration frequencies for all fundamental and higher modes. Such theoretical work is unacceptable to designers until its validity has been established by experiment. For this and other reasons, the British Shipbuilding Research Association have found it necessary to utilise a vibration exciter (Dorey, 1950). Such a machine, capable of exerting pulsating forces of various controlled magnitudes and frequencies, was designed and constructed by Lloyd's Register of Shipping. When this apparatus is mounted, generally at the bow or the stern, the investigators can determine the complete ranges of vertical and horizontal frequencies, obtaining simultaneous records of frequency, amplitude and strain in the hull by apparatus specially developed for this purpose.

Vibration characteristics are affected by the depth of water in which the ship is floating and by the virtual mass effect of the entrained water vibrating with the ship. Model investigations of both these aspects are being pursued in parallel with work on the full scale.

The vibration of ships' masts is a matter of some concern to the Admiralty, who investigate it both in actual ships and by means of half or quarter-scale models. This study is becoming increasingly necessary as the number and weight of specialised aerials attached to the mast increase.

HYDRODYNAMICS

The qualities of an efficient hull propeller combination may be stated briefly as low resistance combined with high propulsive efficiency, minimum loss of speed at any given shaft horsepower in rough water as compared with smooth, and good steering and manœuvring qualities.

The components of ship resistance are generally considered as follows :—

(1) The friction of the water on the hull surface or "skin friction."

(2) The "wave-making" resistance caused by normal pressures on the hull, arising from the inevitable generation of surface waves.

(3) Energy losses arising from the formation of eddies shed from bluff endings of appendages, such as shaft bossings and brackets; in well-designed hulls this component is generally small.

(4) Resistance due to wind acting upon the above-water portion of the hull.

The difference between the total water resistance and that from skin friction is termed the "residuary resistance," and its principal component is the resistance due to wave making.

Our detailed knowledge of the factors that enter into the resistance and propulsion of ships has been derived mainly from model tests in experiment tanks—the form of apparatus introduced by William Froude.

The main uncertainty in this method of predicting the hull resistance lies in the estimation of the full-scale skin friction. Froude assumed that this was the same as the skin friction on a flat surface of the same wetted area as the hull and moving at the same speed. He measured experimentally the resistance of a number of flat planks towed at various speeds, and used the results to draw up a method of extrapolation to predict the full-scale skin friction of ships' hulls. Although this method of prediction has been used in almost all experimental tanks ever since, it is obvious that a full-scale check on the resistance of a ship's hull is very desirable. Simple as this problem sounds, it is extremely difficult in practice. Froude in his famous "Greyhound" experiments tried to obtain full-scale information by towing one ship behind another, but.

although he achieved some success, the results of his trials were not entirely conclusive. The measurement of thrust in the actual ship is a useful, but not entirely satisfactory, guide to the resistance of the hull, because the thrust of the propeller is equal to the hull resistance together with the increase of resistance caused by propeller action. This can be determined on the model scale by suitable tests in the experiment

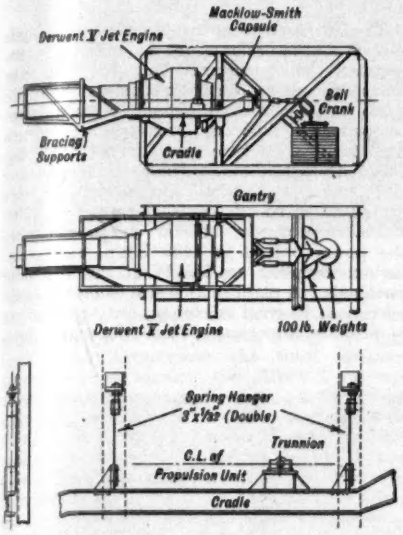


FIG. 6—*The Engine Mountings in the "Lucy Ashton"*

tank, but it is clearly still desirable that some full-scale check should be obtained of hull resistance.

This problem was considered by the British Shipbuilding Research Association, and active work on the subject was begun early in 1950 (Denny, 1951). An ex-Clyde paddle steamer, the "Lucy Ashton," was purchased from the ship breakers. Examination of the hull showed that its proportions, fineness, &c., were suitable for the purpose, and it was estimated that at a speed of 15 knots the resistance would be of the order of 5½ tons. The corresponding Reynolds number was reasonably high, $3{\cdot}75\times10^8$, which would enable a most valuable comparison to be made between full-scale resistance measurements and the resistance predicted from model tests.

There are many possible methods of measuring the resistance of a towed hull. The provision of craft capable of heavy tows at high speeds raises difficulties, and the dynamometer required on board the towed

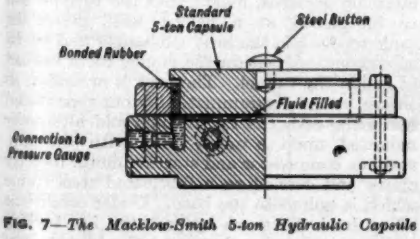


FIG. 7—*The Macklow-Smith 5-ton Hydraulic Capsule*

vessel calls for onerous and conflicting requirements of robustness, accuracy and sensitivity. Owing to the slipstream shed from a towing vessel, this craft must not be directly ahead of the towed craft, thus demanding an outrigger, which presents formidable design problems. Propulsion by airscrews is possible, but the highly periodic thrust developed by an airscrew is difficult to record accurately. Interference effects between airscrews and hull caused by induced and slipstream velocities appear to be unavoidable and are impossible to allow for accurately. Propulsion by jet engines was adopted because they give steady thrusts which are easily and rapidly altered by comparatively simple means. When mounted on a gantry extending beyond the vessel's sides, the discharge from jet engines is clear of the hull and does not affect the water in the immediate vicinity. Further, the thrust recorded can be measured very accurately and therefore gives a close assessment of the hull resistance. These are important advantages and the only disadvantages are high fuel consumption and the noise emission.

It should be clearly understood that measurements of the hull resistance of the "Lucy Ashton" over a wide range of speed were attempted with the fundamental aim of securing information for the comparison of ship resistance and model prediction. Other tests, such as the deduction of virtual mass factors from acceleration and retardation experiments, appendage resistance tests, the effect of seam fairings, &c., were subsidiary aims. Considerable alterations were made to the hull, the shell plating being cleaned and smoothed. Machinery, sponsons, paddle wheels and deckhouses were removed, sand ballast was loaded, and a gantry for carrying jet engines was installed, together with the necessary fuel tank. A sound-resisting cabin was fitted to protect the observers from the high-frequency noise.

The main dimensions of the "Lucy Ashton" are:

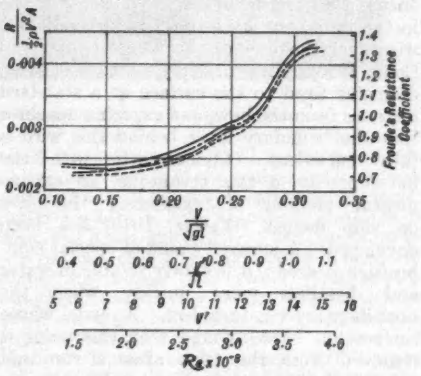
Length between perpendiculars	190ft 6in
Breadth moulded	21ft 0in
Depth moulded	7ft 3in

Most of the experiments were made at a draught of 5ft 2in, corresponding to a displacement in salt water of 390 tons at level trim. The coefficients of form in this condition were as follows:—

Block coefficient	0·685
Prismatic coefficient	0·705
Midship area coefficient	0·972

Four "Derwent V" jet engines were fitted and proved entirely satisfactory. Each engine delivered a thrust of about 3600 lb at a speed of 14,500 r.p.m. The general arrangement of the machinery installation is shown in Fig. 5, and the mountings of all four engines, which were identical, are shown in Fig. 6. Thrust measurement was, of course, of fundamental importance. The device deemed most suitable for this purpose was the Macklow-Smith hydraulic capsule, a drawing of which is shown in Fig. 7, and the recorded pressures were read on 10in diameter high-quality Bourdon gauges. Each of the four thrust-measuring units was calibrated in the dead load calibrating machine at the N.P.L. and *in situ* during the trials by means of special calibrating gear.

Records were taken of ships' speed, wind speed and direction, rudder angles, &c., by the most accurate means available, and the experiments were run over the measured mile course in the Gareloch. Roughness measurements were made over representative areas of the hull surface. Sample results



R_e Reynolds number, R resistance, ρ density, A wetted surface area, V velocity (general), V' speed in knots, g acceleration due to gravity, l length of ship.

Froude's resistance coefficient $= \dfrac{2938R'}{\Delta^{2/3}V'^2}$ where V' is as above, R' is resistance in tons, and Δ is displacement of ship in tons.

Comparison of resistance curves for the four naked hull conditions.

———— Sharp seams, red oxide.
———..——— Sharp seams, aluminium paint.
—·—·—·— Faired seams, red oxide.
– – – – – – Faired seams, aluminium paint.

FIG. 9—*B.S.R.A. Resistance Experiments on the "Lucy Ashton"*

obtained are shown in Fig. 9, where ship results (corrected for wind and to a standard temperature of 59 deg. Fah.) are given.

Before I leave the subject of model and full-scale tests on ship resistance I must mention an important recent development in experiment tank technique. As many of you probably know, skin friction is associated

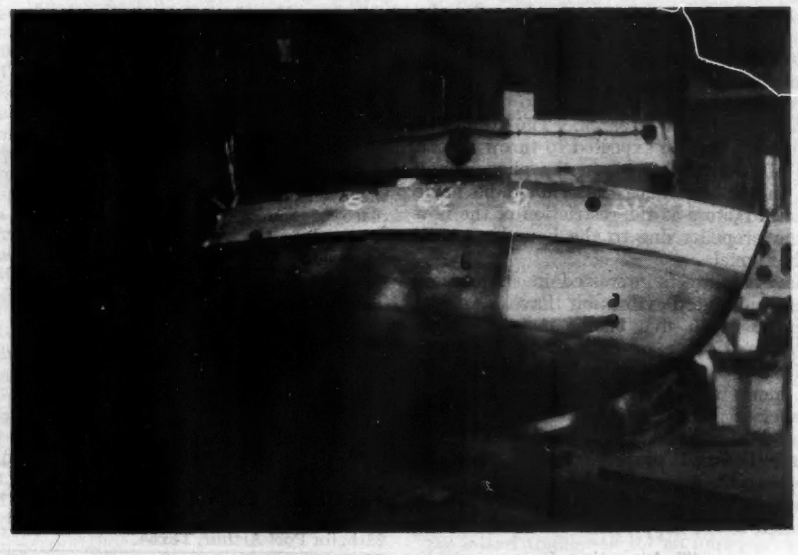


FIG. 8—*Detection of Laminar Flow on Ship Models*

with the kind of flow in the boundary layer; whereas at low Reynolds numbers the boundary layer is laminar, at high Reynolds numbers it is almost entirely turbulent and the skin friction is much higher than it would be if the layer were laminar at these high Reynolds numbers. On models of the size commonly used in experiment tanks the boundary layer may be partly laminar and partly turbulent, whereas on full-scale ships only a negligibly small portion of the boundary layer is laminar, the greater part of it being turbulent. Therefore, unless we know how much of the boundary layer is laminar in the model test, we shall be in error in predicting the full-scale skin friction resistance from that measured in the tank. It has recently become standard practice to ensure that the boundary layer is turbulent in the tank tests by introducing a small trip wire near the bow of the model (Allan and Conn, 1950). This is simply a wire of 0·036in diameter fixed to the surface at a standard distance from the bow, and experiments show that the boundary layer behind this wire is fully turbulent. Concurrently with the development of this technique, an experimental method of examining the flow on ship models (Walker, 1949) has been developed. A sprayed paint of special composition is used; it is slowly soluble in water and dissolves more quickly when the boundary layer is turbulent. A model whose surface has been covered with this paint is removed from the tank after a run and examined. There is a distinct difference in appearance between the regions in which the boundary layer is laminar and turbulent. Fig. 8 shows the laminar area, light in colour forward of the trip wire, and abaft is the dark coloured area of turbulent flow.

Propellers.—Except for relatively minor and exceptional vessels, the screw propeller remains the accepted method of propelling ships. Propellers are generally designed in practice from the results derived from methodical "open water" tests in the experiment tank, in which the thrust and torque are measured, and the propeller is towed in such a way as to be free from interference from the hull. The joint performance of propeller and hull as a combination can be obtained on the model scale by "self-propulsion" tests on the tank carriage, in which the model is power driven by its own motor.

As a result of cavitation research the optimum design of propeller for any class of ship to suppress or reduce cavitation can be confidently determined. There are, however, still some unknown factors, and, under the auspices of the International Conference of Ship Tank Superintendents, a comprehensive research is in progress in different countries to obtain a closer approach to ship conditions by tunnel research. The results of these tests may be expected to throw a good deal of additional light on the phenomenon and on the allowance that should be made for such factors as the restriction of the flow to the propeller due to the boundary walls of the tunnel.

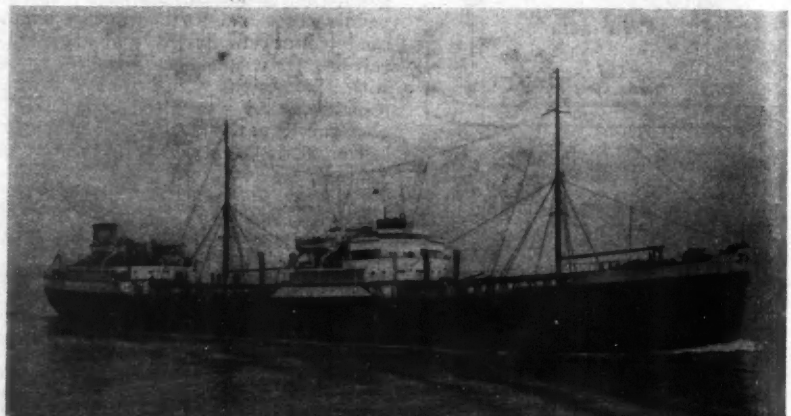
Naval architects interested in suppressing propeller-induced vibration have designed propellers with five blades instead of the more usual three or four blades. Greater cavitation can result from blade interference and more frequent pressure changes if the number of blades is increased. Cavitation research has guided the production of designs of multi-bladed propellers which compare satisfactorily as regards efficiency with propellers of fewer blades, and has thus contributed to the suppression of vibration.

(To be continued)

Marine Gas Turbine in M.V. "Auris"

A gas turbine alternator unit designed and built by the British Thomson-Houston Company, Ltd., in conjunction with Anglo-Saxon Petroleum Company, Ltd., was fitted on board the diesel-electric oil tanker "Auris" last year, one of the ship's four diesel engines being removed for that purpose. In the meantime, the ship has completed one round voyage during which the gas turbine set ran continuously, and in this article the main particulars of the gas turbine set are recalled and a short account given of its behaviour when operating under service conditions.

NEARLY one year ago we visited the works of the British Thomson-Houston Company, Ltd., to witness part of the shop trials of the gas turbine alternator set* which the company had built in association with Mr. John Lamb, the chief of the Shell marine research and development department. Upon the satisfactory completion of the trials the plant was dismantled and forwarded to Tyneside for installation on board the Shell oil tanker "Auris" for the vessel to become the first merchant ship to employ a gas turbine as a main propulsion unit. Last week, at the invitation of the Shell Petroleum Company, Ltd., we boarded the "Auris" at Southampton and were able to make a short sea voyage and inspect the gas turbine when working under normal sea-going conditions.



M.V. "AURIS"

The "Auris," seen in our illustration, was built and engined by R. and W. Hawthorn, Leslie and Co., Ltd., to the requirements of the Anglo-Saxon Petroleum Company, Ltd., and commissioned in 1948. The ship was fitted with propelling machinery consisting of four eight-cylinder Hawthorn-Sulzer four-stroke-cycle diesel engines, each developing 1105 b.h.p. and direct coupled to a B.T.H. double-unit, 830kW alternator which supplied power to a B.T.H. single-unit a.c. propulsion motor of 3750 s.h.p. at 120 r.p.m. This particular form of machinery installation was adopted not only to experiment with the burning of boiler fuels in high-speed engines, but with the intention of facilitating the eventual installation of a gas turbine in place of one of the diesel units. The ship returned to the yard of her builders for the alterations to the machinery arrangements, and our photographs show the l.p. turbine, alternator and bedplate, and a view of the instrument panel and control valves. The inner starboard diesel alternator set was removed and the gas turbine installed in three sections, an operation which called for extreme accuracy imposed by the limits of space. Sea trials followed, during which the diesel engines were shut down and the ship was propelled solely by the gas turbine alternator set, a speed of over 7 knots being attained with the ship fully laden. No additional adjustments were found necessary and the ship sailed, on October 28th, for Port Arthur, Texas.

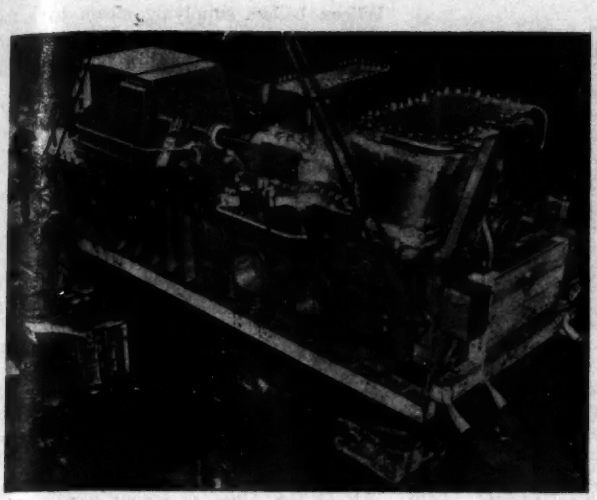
* THE ENGINEER, February 23, 1951, pages 250–252.

The gas turbine operates on the open-cycle system and is designed for an initial gas temperature which ensures long life for those parts exposed to the peak temperature of the cycle. The set was designed for an ambient temperature of 68 deg. Fah. and a maximum h.p. turbine inlet temperature of 1200 deg. Fah., while the h.p. turbine and compressor and the l.p. turbine and alternator were designed for speeds of 6000 r.p.m. and 3000 r.p.m. respectively. Under design conditions the power output is 1200 b.h.p. at the l.p. turbine coupling, or 860kW at the alternator terminals. A plant of this size cannot give the maximum thermal efficiency, but this was not of primary importance, since the main object of the experiment was to obtain a measure of the reliability of the new prime mover under service conditions.

Although provision was made in the initial design of the ship for the fitting of a gas turbine, it was recognised that the disposition of the space available would be a major factor in siting the turbine components, and that the resulting general lay-out would not be ideal. Piping arrangements in connection with the three remaining diesel units and for other auxiliary services, meant that the turbine had to be placed at a height well above the tank top, while the heat exchanger had to be accommodated within the engine-room instead of inside the funnel. The unit is arranged, as shown in the diagrammatic lay-out reproduced herewith, with the l.p. turbine and alternator mounted upon a main base with the h.p. turbine, compressor and starting motor directly above and carried on a fabricated steel frame which is bolted to the base. Under conditions of no load the gases by-pass the l.p. turbine and pass through a by-pass valve direct from the h.p. turbine to the heat exchanger. Twin air outlet drums, in each of which is fitted a combustion chamber with its single oil burner, are mounted on the l.p. turbine exhaust and, in turn, are surmounted by the contra-flow heat exchanger consisting of widely pitched steel tubes and a single inlet drum.

Voyage Results

The outward voyage lasted twenty-two days during which the gas turbine ran continuously in conjunction with the three diesel engines



L.P. Turbine, Alternator and Bedplate

Instrument Panel and Control Valves

and the ship covered the 4905 miles at an average speed of 9·21 knots. When the ship berthed at Avonmouth the total distance travelled since leaving the River Tyne was 10,929 sea miles, which occupied forty-four days, during which the gas turbine set operated without an involuntary stop. Rough weather was encountered during the voyage and it was noted that sea spray often swept over the compressor air intake, but this did not affect the running of the turbine. Since then the ship has visited a number of British and Continental ports, so that the ship has now logged 13,211 sea miles and the machinery has operated for 1391 hours. During the outward and homeward voyages the turbine operated on diesel oil of about 50 seconds Redwood No. 1 at 100 deg. Fah., but in home waters boiler fuel of 1500 seconds viscosity has been used and will continue to be used on the next voyage.

The boiler fuel for the turbine is treated in the same manner, which has proved so successful in enabling heavy fuel to be used in diesel engines. From the bunkers, the boiler oil passes through a closed coil thermostatically controlled steam heater, where the temperature is raised to 180 deg. Fah., the oil is then treated by a De Laval centrifugal purifier and clarifier units arranged in series. In the purifier water and heavy solids are removed from the fuel while the finely divided solids are removed in the clarifier so that the fuel, when delivered to the service tanks, has an ash content of 0·02 per cent. The fuel is injected into the turbine at a pressure of 350 lb per square inch and a temperature of 220 deg. Fah.

Atmospheric temperature ranged from 52 deg. Fah. to 81 deg. Fah., and the output of the turbine varied only to the extent expected. When on test the overall thermal efficiency of the unit was 21·4 per cent, which is equivalent to a consumption of 0·675 lb of boiler fuel per brake horsepower per hour at the turbine coupling, while the fuel consumption during the voyage averaged 0·75 lb per brake horsepower per hour, which is roughly the same as that of a steam turbine installation of equal rating. The consumption of lubricating oil was returned at the low figure of $\frac{1}{4}$ gallon per day.

During the demonstration run at Southampton it was noted that, with an output of 300kW at the alternator terminals, the h.p. turbine gas inlet pressure was 25 lb per square inch and the temperature 920 deg. Fah., while the gas outlet temperature was 650 deg. Fah. At the l.p. turbine outlet the gas temperature was 550 deg. Fah., and the final exhaust temperature was 360 deg. Fah. There was a marked absence of vibration with the turbine running and there was only a slight amount of noise from the air intake. Noise from this source had been effectively suppressed by fitting a special silencer designed by Burgess Products Company, Ltd., in conjunction with the British Thomson-Houston Company, Ltd. The silencer, which is fitted between the air intake mushroom on the boat deck and the compressor inlet, was designed to reduce noise to a reasonable level, and has a bore of 30in, an outside diameter of 40in, and a straight length of 25ft, made up of five sections, each 5ft long, in order to facilitate fitting on board the vessel. The sound-absorbent material is covered by a double thickness of specially perforated brass, and the straight-through design gives an unrestricted air flow. During the demonstration run gauges indicated that the friction loss between the inlet cowl and the compressor was of the order of 1in water gauge under the conditions existing.

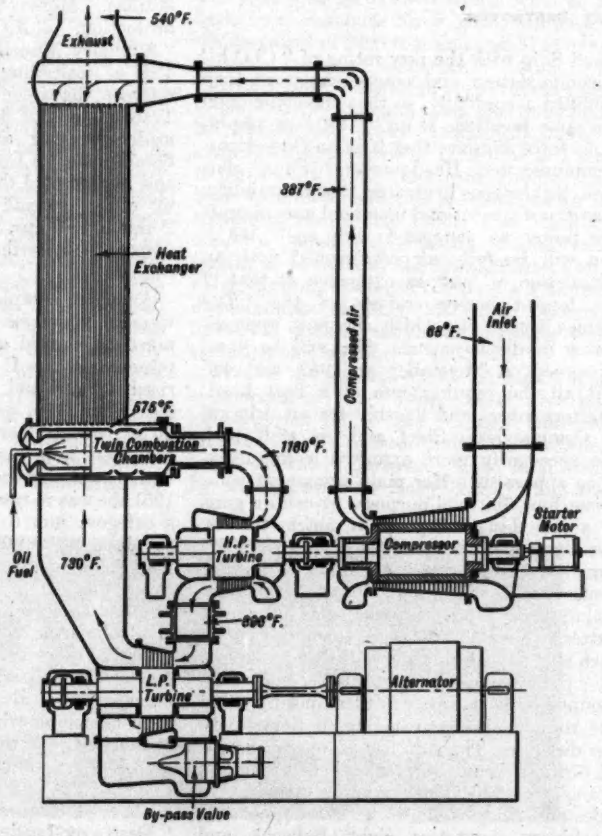


Diagram of Gas Turbine Set

Prestwick and Renfrew Airports

The Minister of Civil Aviation, the Hon. J. S. Maclay, and the Minister of State for Scottish Affairs, the Earl of Home, recently met the Scottish Advisory Council for Civil Aviation to discuss proposals concerning Prestwick and Renfrew airports. The Minister of Civil Aviation expressed agreement that, until a second main runway had been built, Prestwick could not operate at full efficiency. He pointed out that the present economic situation imposed strict limits on capital expenditure, but the first and most urgent problem at Prestwick was the improvement in the usable length of the main instrument runway. The first two elements in the problem, namely, the elimination of an undulation and the extension in the paved surface to 7000ft, he had found almost completed when he took office, and the next step was to construct the 1000ft over-run to the west. That would make the runway suitable for take-off in still air of all aircraft which were now flying, or, as far as he knew, were on the drawing boards of any country. Negotiations were in progress for a contract for the over-run. The Minister went on to say that the principal problem was what to do with the Ayr–Kilmarnock road running across the end of the runway, between it and the over-run. The answer could be provided by a tunnel scheme, but that would be expensive and could not be undertaken until the new subsidiary runway had been built. An alternative proposal was to construct a short temporary stretch of road, parallel to and a little to the west of the existing Ayr–Kilmarnock road, and at the same time lower the existing road which would be incorporated in the compacted over-run. Road traffic would be controlled as at present, and the proposal would not prejudice any ultimate decision between a detour and the construction of a tunnel. The Minister also referred to changes at Renfrew Airport, saying that minor improvements to the existing terminal buildings would be made immediately. Plans were also being considered for the construction of new terminal buildings for inland traffic and for an improved control tower.

Naval Construction in 1951

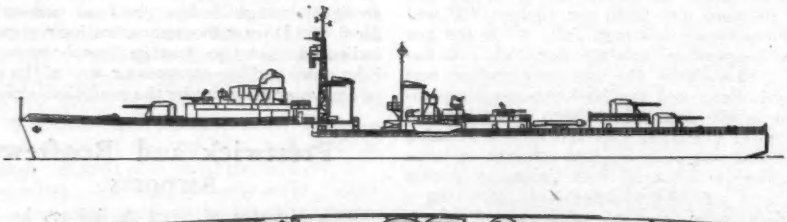
By RAYMOND V. B. BLACKMAN

No. III—(*Concluded from page 128, January 25th*)

United States

THE United States new naval construction programme announced in 1951 provided for the building of some 260 warships. They included a heavy aircraft carrier, two ocean escorts, seven submarines, 166 minesweepers, thirty minesweeping boats, twelve fleet oilers, two rocket ships, an icebreaker, sixty-six landing ships, and thirty smaller vessels. The projected reconstruction and modernisation programme included the conversion of 291 existing vessels comprising six "Essex" class aircraft carriers, twelve cruisers, two guided missile cruisers, 194 destroyers, twelve radar picket destroyers, thirty-one landing craft and thirty-four smaller vessels. Orders for the conversion or modernisation of 102 vessels, including three "Essex" class aircraft carriers, were issued to ten naval shipyards and a private shipyard.

A giant flush-decked aircraft carrier with a retractable bridge is to be built for the United States Navy. Known as a "heavy aircraft carrier" and designated "CVC 59," she is named "James V. Forrestal" after the Secretary of Defence who was in office when the heavy aircraft carrier "United States" ("CVA 58") was named on February 2, 1949, thus justifying his, and the U.S. Navy's, faith in an aircraft carrier of approximately the size which is now in fact to be built. It will be recalled that the "United States" was ordered on August 10, 1948, and laid down at the yard of the Newport News Company on April 19, 1949, but was cancelled on April 23, 1949, only four days later.



French Anti-Aircraft Destroyer

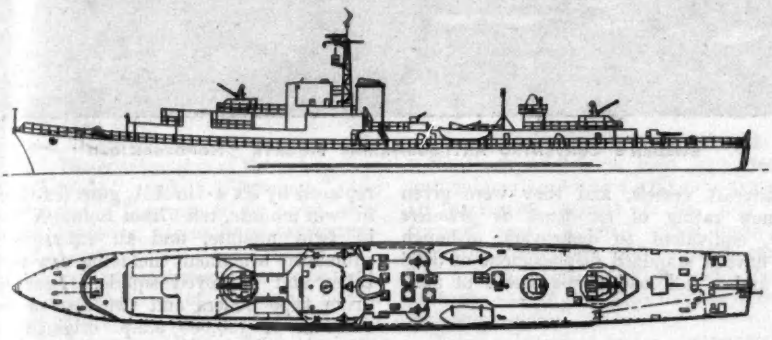
The design of the "James V. Forrestal," which is reported to be costing 235,000,000 dollars, calls for a runway about 25ft longer than that provided in the largest existing "large aircraft carriers" ("CVB") of the "Midway" class, so that larger and heavier carrier-based naval aircraft of the newest designs can be operated from her decks. She will have increased catapult and arresting capacity, larger elevators, and higher hangar decks. There will be added armour protection and improvement underwater protection. She is being built by the Newport News S.B. and D.D. Company and will have a standard displacement of 59,900 tons with an overall length of 1040ft, a beam of 128ft at the interline, and an extreme width at one point of 252ft. She is expected to be completed approximately thirty-six months after the laying of her keel next summer. It is understood that the ship will not be dissimilar to the cancelled "United States," and the material assembled for the latter will probably be used in the construction. The Secretary of the Navy has declared that this ship, which will be the largest and fastest warship in the world, does not represent the largest that the U.S. Navy will some day build. It is reported that two additional heavy aircraft carriers may be built, but it is officially stated that the Navy is planning to see how successful the first vessel of this kind turns out before ordering others.

On January 29, 1951, there was launched from the yard of the Bethlehem Company, Quincy, Mass., an entirely new kind of warship which cannot be described better than simply as a fleet flagship with no other primary function. She is the U.S.S. "Northampton," of 17,000 tons standard displacement. Laid down on August 31, 1944, this vessel was originally designed as a heavy cruiser of the "Baltimore" class, and was to have been completed as one of the modified "Oregon City" class, numbered "CA 125." She was officially 56·2 per cent constructed when she was cancelled on August 11, 1945. But she was re-ordered on July 1, 1948, and redesignated as a Task Force Command Ship with the new rating of "CLC 1." Accommodation and equipment were then modified accordingly, so that she could fulfil the same functions as an "AGC," or amphibious force flagship, that is as an Operations-Communications-Headquarters Ship, but with higher speed, greater manœuvrability, heavier armament and increased anti-aircraft fire power as compared with an "AGC." She will be fully air conditioned with an installation at least as extensive as that of the largest heavy cruisers of the "Des Moines" class, to which she now approximates in displacement. She will be commissioned on November 30, 1952, and will suit all the requirements of a fleet headquarters vessel and flagship for an Admiral or Commander-in-Chief and his staff with the necessarily more extensive communications apparatus. Her main armament comprises four 5in dual-purpose, 54-calibre guns of a new design disposed in single turrets, two forward and two aft, "B" and "X" guns superfiring over "A" and "Y" guns, respectively. The anti-aircraft armament includes eight 3in weapons, also of a new pattern, disposed in twin turrets, two on each side amidships abreast the single funnel. A "pyramidoid" control tower-mast surmounts both the after control position and the rounded bridge receding in tiers up to the director. The ship has an overall length of 676ft, a beam of 71ft and a maximum draught of 25ft. Her armour includes 6in sides and 3in plus 2in decks. Her propelling machinery comprises eight Babcock and Wilcox boilers supplying steam to a four-shaft arrangement of General Electric geared turbines developing 120,000 s.h.p. and equal to a speed of 33 knots.

For centuries it has been recognised that each category of warship must be designed to carry out some one main principal function, but the idea that "command" is itself a tactical function, requiring a specially designed flagship, is very modern and admirals have continued to sit astride the fleet and weapons under their command in a ship designated a flagship but actually designed to fulfil some specific tactical purpose and on this particular occasion to spearhead the fighting line. There have been several admirals who have not held with the standard theory that the officer in command of a fleet ought to be confined in the conning tower of a battleship, which necessarily was required to hold her station in rigid formation. Conditions in the second world war obliged the Allies to invent a wide assortment of amphibious ships and to control the great fleets of tank-landing ships and utility landing craft a number of merchant ships were converted to serve as flagships. These "A.G.C.s" included several former ocean liners, but the "A.G.C.s" retained in the fleet after the war are all similar, being converted Maritime Commission "C2-S-B1" or "C2-S-AJ1" freighters. These vessels have no function other than to serve as flagships and one, the "Mount Olympus," relieved the heavy cruiser "Columbus" as flagship of the Commander-in-Chief, American Forces, Eastern Atlantic and Mediterranean. Originally rated as Combined-Operations-Communications Headquarters ships, these vessels are fitted as flagships for Chiefs of Combined Forces, with accommodation for Marine or Army units attached. The radar and radio equipment is exceptionally elaborate. While they can be and are useful as administrative flagships, they are too slow to serve at sea with task forces other than amphibious flotillas. Moreover, they have no armour protection. "A.G.C." officially stood for "Auxiliary, Miscellaneous, Communications." This is misleading now in that it seems to relegate these command ships to the Fleet Train instead of denoting an administrative leader wearing an admiral's flag. It is because the "A.G.C." ships are slow, crowded and unprotected that they are to be replaced by others specially designed as Task Fleet Command Ships, of which the "Northampton," described above, is the forerunner.

Another completely novel category of warship, which for lack of any other standard must be classed as a light cruiser for the present, is the U.S.S. "Norfolk." Authorised in 1947 and ordered on November 17, 1948, this ship, which is under construction at the Norfolk Navy Shipyard, was originally described as a "cruiser," hunter-killer ship, with the designation of "CLK 1"; but in 1951 she was re-rated as a "destroyer leader," a category new to the U.S. Navy List, with the designation "DL 1." Her standard displacement is given as 5530 tons, with an overall length of 540ft and a speed of 34 knots. Designed as a special category of anti-submarine vessel of cruiser size and entirely new type, she will cost about 40,000,000 dollars. She is scheduled to be commissioned about June 1, 1952. Two such anti-submarine cruisers were originally authorised, but the "Norfolk's" sister ship, "CLK 2," to have been built by the Philadelphia Navy Shipyard, was deferred in 1949. In essence it would seem that the "Destroyer-Leader" category of warship

is a lighter class of command ship. The four large destroyers of the "Mitcher" class were also re-rated as destroyer leaders in 1951, while building. The "Mark A. Mitcher" and "John S. McCain," both under construction by the Bath Iron Works Corporation, and "Willis A. Lee," laid down on February 1, 1950, and "Wilkinson," both being built by the Bethlehem Company, Quincy, were originally designated "DD 927," "DD 928," "DD 929," and "DD 930," respectively, but are now numbered "DL 1," "DL 2," "DL 3," and "DL 4." They will be the largest destroyers ever built in the United States and in the world; indeed, they will be larger than some ships rated as light cruisers in other countries. Reported to be costing 15,000,000 dollars each, they are of a new design and are being specifically constructed as a long-range fleet type for anti-submarine duties. They will have a standard displacement of 3075 tons and a full load displacement of 4400 tons, with a length between perpendiculars of 450ft, an overall length of 493ft, a beam of 49ft, and a draught of 20ft. Authorised under the 1948 programme, all were ordered on August 3, 1948, and are scheduled to be delivered to the U.S. Navy in 1952.



FRENCH ANTI-SUBMARINE FRIGATE

Late in 1951 the destroyer "Timmerman," of more orthodox size and type, was completed to a new design. She is fitted with "more powerful machinery and light weight," employing much higher temperatures and pressures than hitherto. The reduction in weight goes far beyond anything previously attempted to determine exactly how light naval propelling machinery can be without sacrificing the required ruggedness. The ship is largely experimental, several novel ideas of marine engineering having been incorporated. At base she is a modified version of the original "Gearing" class destroyer design, and has been officially described as the prototype of a new class. She was built by the Bath Iron Works Corporation, being laid down in October, 1945, launched on "Armed Forces Day" (May 19, 1951), and commissioned on September 1, 1951. She has a standard displacement of 2425 tons with a length of 390½ft, a beam of 40½ft and a draught of 12½ft.

The 1951 new construction programme includes two new ocean escort vessels, rated as "DE.s." They are officially described as prototypes for new and modern anti-submarine vessels and presumably will approximately correspond to the A/S frigates being built in Great Britain. The estimated cost is 15,000,000 dollars per vessel, or as much as the largest destroyer ordered in 1948, an indication of how much shipbuilding costs have gone up in three years. They will have a displacement of 1450 tons and are to be lavishly equipped with electronic gear. The vessel to be built by the Bath Iron Works is to be named "Dealey" and designated "DE 1006."

It was officially stated in 1951 that seven submarines are included in the new building programme. The U.S. Navy Bureau of Ships announced that a contract for the first nuclear-powered submarine had been awarded to the Electric Boat Company, Groton, Connecticut. She will displace 2500 tons and cost 40,000,000 dollars. Three other submarines of novel design are in hand. The hydrogen peroxide powered type, to be built by Portsmouth Navy Yard, will have a displacement of 2200 tons and cost 37,000,000 dollars. The "Albacore," designated "AG(SS) 569," the high-speed underwater target and experimental craft, also to be built by Portsmouth Navy Yard, will have a standard displacement of 1218 tons and cost 10,000,000 dollars. Her construction has been authorised and she is scheduled to be completed on July 2, 1953. The "AG(SS) 570," a small experimental coastal submarine to be built by the Electric Boat Company, Groton, Conn., is to have a standard displacement of only 250 tons. Costing 3,000,000 dollars, she is to complete construction on December 1, 1952.

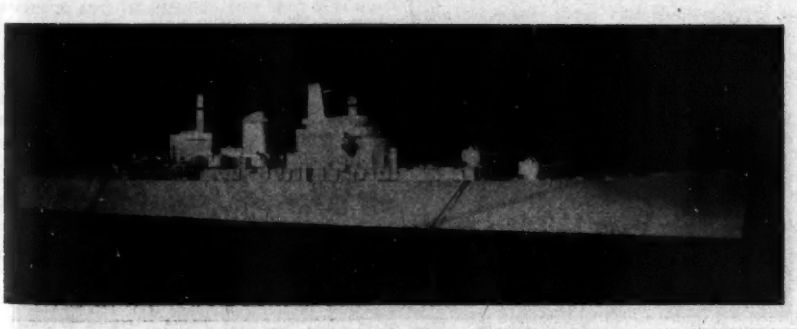
Five of the six high-speed "Attack" type submarines of the "Tang" class were put afloat during 1951. The "Tang," launched on June 19th, "Wahoo," launched on October 16th, and "Gudgeon" have been built by the Portsmouth Navy Yard, while the "Trigger," launched on June 14th, "Trout," launched on August 21st, and "Harder," launched on December 3rd, have been built by the Electric Boat Company, Groton. They have standard displacement of 1570 to 1615 tons with an overall length of 268ft and an armament including six 21in torpedo tubes. With diesel-electric propelling machinery designed for 15 to 20 knots on the surface and over 17 knots submerged, they are reported in the U.S. to be the fastest submarines afloat. They embody various improvements based on war experience to give higher submerged speeds, and the development of the Schnorkel breathing masts. They are streamlined, deep-diving vessels, but have comparatively short hulls. The "Trigger," laid down on February 24, 1949, at the Connecticut works, is the first of the post-war programme. This class is powered by a compact radial engine now ready after five years of development work, comprising a sixteen-cylinder, two-cycle plant, mounted vertically with four rows of cylinders radially arranged. The engines previously available for use in submarines were approximately twice as heavy and half as large again as this new engine. The hull is shorter than current fleet units, and this shortening is said to contribute to the underwater speed.

Simultaneously three anti-submarine type submarines of medium size are being built. These have letters and numbers instead of names. The "K 1," launched by the Electric Boat Company on March 2, 1951, and commissioned on November 10th, the "K 2," launched on May 2, 1951, and "K 3" were constructed by the Mare Island Navy Shipyard. With a standard displacement of 765 tons and an overall length of 196ft, they are known as "submarine killers," as they were specifically designed for A/S operations.

Two warships of a new kind were ordered from the Philadelphia Navy Yard in 1951. These minesweeper depot ships are designated "XMAP 1" and "XMAP 2." They have displacement of 3000 tons (light) and are officially described as "sweeper devices." No fewer than forty-three minesweepers classed as "AM" are being built by fourteen different shipyards. Of wooden construction, they will have a length of 165ft. Another sixty-three auxiliary motor minesweepers, rated as "AMS," are to be built by eighteen different yards; they have a length of 136ft. Thirty highly specialised minesweeping boats with a length of 57ft are also to be built at various yards.

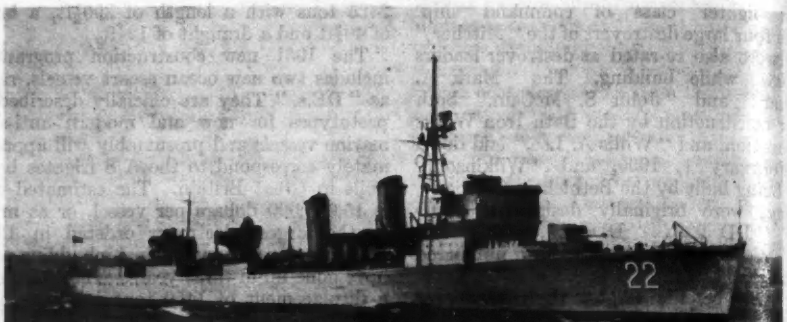
Four motor torpedo boats, the first to be built in the United States since the end of the war, were completed in 1951. "PT 809," "PT 810," "PT 811," and "PT 812," built by the Electric Boat Company, Groton; the Bath Iron Works Corporation; John Trumpy and Sons, Annapolis; and Philadelphia Naval Shipyard, respectively, were purposely built by four different builders to experimental designs. With a displacement of 75 tons, they have lengths of 95ft to 105ft and beams of 24ft to 25ft, and carry two 40mm and four 20mm guns each. Of all aluminium construction, they are larger than the wartime "PT.s," of which only four now survive for instructional purposes, with greater displacements, range, fire power and stability. "PT 811" was accepted on March 6, 1951. "PT 810" is of half-welded and half-riveted hull construction. The four boats constitute Motor Torpedo Boat Squadron One.

Three giant transports were completed or neared completion at the end of the year. The "Barrett" (ex-"President Jackson") "AP 196"; "Geiger" (ex-"President



MODEL OF U.S. COMMAND SHIP "NORTHAMPTON"

Adams "), "AP 197"; and "Upshur" (ex-"President Hayes"), "AP 198," were originally laid down as passenger ships for the American President Lines, but were taken over by the Navy to be completed as troop transports. They are Maritime Administration "P2-S1-DN1" type ships with a full-load displacement of 19,600 tons and a one-shaft arrangement of geared turbines developing 13,750 s.h.p. and giving a speed of 19 knots. The "Upshur" was launched on January 19, 1951, and the "Barrett" was completed on December 15, 1951. All were built by the New York Shipbuilding Corporation, Camden, N.J.



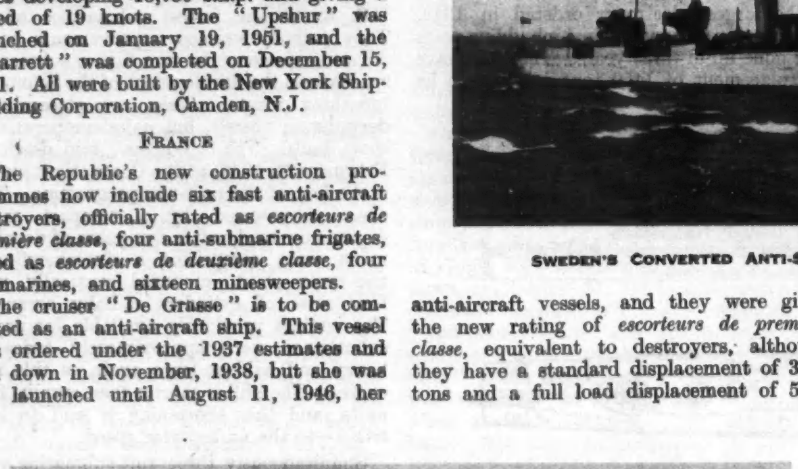
SWEDEN'S CONVERTED ANTI-SUBMARINE FRIGATE "NORDENSKJOLD"

FRANCE

The Republic's new construction programmes now include six fast anti-aircraft destroyers, officially rated as *escorteurs de première classe*, four anti-submarine frigates, rated as *escorteurs de deuxième classe*, four submarines, and sixteen minesweepers.

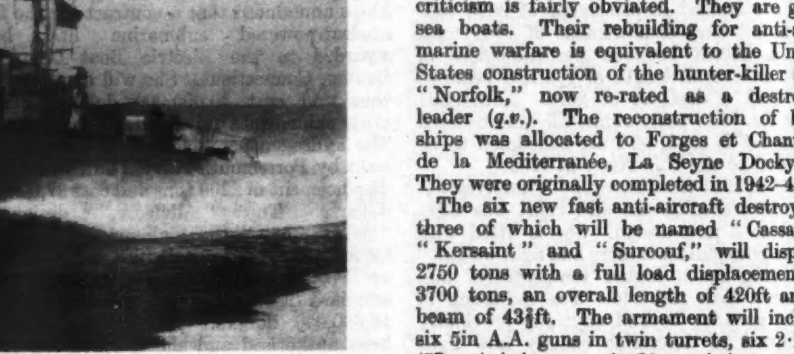
The cruiser "De Grasse" is to be completed as an anti-aircraft ship. This vessel was ordered under the 1937 estimates and laid down in November, 1938, but she was not launched until August 11, 1946, her construction having been suspended during the enemy occupation of Lorient and resumed in 1946 until the launching of the vessel. Building was then again stopped pending study of new anti-aircraft equipment and owing to the financial situation. Construction was again resumed in 1951 and she is to be completed in Brest dockyard as an anti-aircraft cruiser with modified armament. Built by Lorient and engined by A. and C. de Bretagne, she will finally have a standard displacement of 7000 tons with a full load displacement of 9000 tons, a length of 592ft, a beam of 60½ft and a draught of 18ft. Her new armament will comprise sixteen 5in A.A. guns, twenty 57mm A.A. weapons, and Bofors pieces, as well as six 21·7in torpedo tubes. The propelling machinery consists of Rateau-Chantiers de Bretagne geared turbines turning two shafts and aggregating 110,000 s.h.p. equal to a speed of 33·5 knots.

The two former Italian light cruisers "Chateaurenault" (ex-"Attilio Regolo") and "Guichen" (ex-"Scipione Africano") were taken in hand in the summer of 1951 for reconstruction as anti-submarine and anti-aircraft vessels, and they were given the new rating of *escorteurs de première classe*, equivalent to destroyers, although they have a standard displacement of 3606 tons and a full load displacement of 5223 tons with an overall length of 465ft, a beam of 46½ft, and a maximum draught of 17½ft. The former armament of eight 5·3in guns, eight 37mm A.A. guns, eight 20mm A.A. pieces, and eight 21in torpedo tubes is being replaced by six 4·1in A.A. guns (ex-German) in twin mounts, ten 57mm Bofors A.A. guns in twin mounts, and an extensive anti-submarine armament including new torpedo tubes and improved squids. Four three-drum type boilers and two sets of geared turbines of 120,000 s.h.p. originally gave these vessels a trial speed of 38·3 knots. With 1400 tons of oil fuel they have a range of 3600 miles at 18 knots, and in their new rating they will be very formidable destroyers indeed. They were acquired in 1948 as France's share of surrendered Italian warship tonnage. As cruisers they were lightly constructed with alloy superstructure and no armour, strength and protection having been sacrificed to speed, but as destroyers this criticism is fairly obviated. They are good sea boats. Their rebuilding for anti-submarine warfare is equivalent to the United States construction of the hunter-killer ship "Norfolk," now re-rated as a destroyer leader (*q.v.*). The reconstruction of both ships was allocated to Forges et Chantiers de la Mediterranée, La Seyne Dockyard. They were originally completed in 1942–43.



U.S. MOTOR TORPEDO BOAT "PT810"

The six new fast anti-aircraft destroyers, three of which will be named "Cassard," "Kersaint" and "Surcouf," will displace 2750 tons with a full load displacement of 3700 tons, an overall length of 420ft and a beam of 43½ft. The armament will include six 5in A.A. guns in twin turrets, six 2·25in (57mm) A.A. guns, six 20mm A.A. weapons, four 21·7in torpedo tubes, anti-submarine weapons similar to the hedgehog or squid, and other new equipment. The propelling machinery will comprise a two-shaft arrangement of geared turbines of 63,000 s.h.p. designed for a speed of 34 knots. One was authorised under the 1949 programme, one



SWEDEN'S TORPEDO BOAT "T101"

in 1950, and the remaining four in 1951. These vessels have been largely inspired by the very successful "Volta" and "Mogador" of 1939.

The four ocean-going anti-submarine frigates will have a standard displacement of 1250 tons with a full load displacement of 1702 tons, a length of 315ft and a beam of 33½ft. The armament will comprise one 4·1in gun aft, four 2·25in A.A. weapons in twin mounts, and a very powerful anti-submarine battery. The propelling machinery will consist of geared turbines of 20,000 s.h.p., equal to a speed of 26 knots. They were designed as sea-going convoy escort vessels with a very large radius of action.

Improved replicas of the German "XX" type, the four new submarines, which are to be built at Cherbourg, will displace 1400 tons. All are on order. Two were authorised under the 1949 programme and two in 1950. They are described as ocean-going submarines. The construction of the submarines "L'Andromede" and "L'Artemus" has been resumed. They are to be given more powerful batteries, streamlined superstructure and a snort.

Seventeen new minesweepers are to be built. With a displacement of 400 tons and a length of 137½ft they will be of wooden and light alloy construction. Two at least, probably more, will be propelled by a new kind of engine, a gas turbine with Pescara diesel generator. The remainder will be diesel driven similar to those being built in the United States, Great Britain, Canada and the Netherlands, of which the plans are said to be similar for all.

Italy

It is reported that under the five-year programme of construction Italy is to have two new cruisers with special anti-aircraft installations to replace over-age ships, two new light anti-aircraft units, six destroyers equipped with anti-aircraft and anti-submarine weapons, two fast anti-submarine frigates, and twelve magnetic minesweepers.

The six new destroyers will have a standard displacement of 2800 tons (3500 tons full load) with a length of 393¾ft, a beam of 42¾ft and a draught of 11½ft. The armament will include four 5·3in A.A. guns and eight 40mm A.A. weapons, and steam turbines of 60,000 s.h.p. will give them a speed of 34 knots.

Rated as "Avvisi Scorta," the two new anti-submarine frigates will displace 1700 tons with a length of 315ft, a beam of 37¾ft and a draught of 11ft. They will carry four 3·5in guns, four 40mm A.A. weapons and a special anti-submarine armament at a speed of 26 knots, obtained from steam propelling machinery of approximately 20,000 s.h.p.

Netherlands

The Netherlands is producing a force of twelve vessels of a hybrid type akin to both destroyers and fast ocean-going anti-submarine frigates. They have been designed with destroyer lines and are of destroyer displacement and dimensions, but they will have no torpedo tubes, one of the specific features of destroyers, and are specifically intended to be "submarine chasers." The "Amsterdam," "Drenthe," "Friesland," "Gelderland," "Groningen," "Holland," "Limburg," "Noord-Brabant," "Overijsel," "Rotterdam," "Utrecht" and "Zeeland" will also be unusual in that they will have some side armour as well as deck protection, and in this respect they rank with light cruisers. They will have a displacement of 2097 tons (about 3000 tons full load) with an overall length of 371ft, a beam of 37¼ft and a draught of 12½ft. Their armament will include four 4·7in guns (orthodox destroyer calibre), five 57mm A.A. guns and some depth charge throwers. All will be propelled by a two-shaft arrangement of geared turbines, but their power will vary, being of 45,000 s.h.p. in the first four, equal to a speed of 32 knots, and 60,000 s.h.p. in the remaining eight, giving a speed of 35 knots.

Four new submarines are projected. Two are to be built by Rotterdam Drydock Company and two by Wilton-Fijenoord, Schiedam.

Sweden

The displacement of the four large destroyers of improved "Oland" design under construction or projected in Sweden is now given as 2500 tons with a length of 380½ft and a beam of 41ft. The armament includes four 5in A.A. guns, two 57mm A.A. weapons, six 40mm A.A. pieces, and eight 21in torpedo tubes. They are designed for a speed of 35 knots.

The old destroyers "Ehrenskold" and "Nordenskjold" have been converted into anti-submarine frigates with new armament. Of particular interest is the new motor torpedo boat "T 101," which looks like a miniature destroyer. With a displacement of 140 tons, a length of 147½ft and a beam of 19ft, she carries four 21in torpedo tubes and two 40mm guns.

Three submarines under construction, the "Hajen," "Sälen" and "Valen," which will have a displacement of 800 tons, are to be equipped with Schnorkel breathing mast tubes and will have fast diving capabilities.

Spain

Two destroyers, the "Alava" and "Liniers," of 1635 tons (2086 tons full load), were completed and entered service in 1951, while four more, the "Audaz," "Meteoro," "Osada" and "Rayo," of 1100 tons (1475 tons full load), were launched during the year.

The construction of a new kind of ship rated as *corbetas*, is projected. These interesting ships will displace 880 tons with an overall length of 242½ft, a beam of 39½ft and a draught of 8½ft. They will carry a 4·1in gun, two 37mm weapons in a twin mounting, twelve 20mm pieces in quadruple mountings, and four depth charge throwers. Diesels will give a speed of 18·5 knots.

Venezuela

Two large destroyers, the "Nueva Esparta" and "Zulia," were laid down at Vickers-Armstrongs, Barrow-in-Furness, on July 24, 1951. They will displace 2600 tons and cost £2,500,000 each. A contract for a third vessel of the class was signed at Caracas, Venezuela, also on July 24th, and is also to be constructed at Barrow.

Peru

The "Marañon" and "Ucayali," river gunboats of unusual type, were launched from the Woolston shipyard of John I. Thornycroft and Co., Southampton, in April and March and completed in July and June, 1951, respectively. Of 365 tons full-load displacement, they have a waterline length of 154¾ft, a beam of 32ft and a maximum draught of only 4ft. They each carry two 3in dual-purpose guns and seven 20mm A.A. weapons (two twin and three single). Two sets of British Polar diesel engines of 800 b.h.p. give them a normal speed of 12 knots. They have a range of 6000 miles without refuelling. The superstructure is of aluminium alloy and they have mechanical ventilation. They were specially designed with a very shallow draught for employment on police duties on the Upper Amazon and for carrying naval officers and men under tropical conditions. Thornycrofts, of course, are specialists in this type of craft, having built several Yangtse gunboats for the Royal Navy before the war.

A Precast Concrete Turbine House Structure

The structural design of the new Acton Lane "B" power station of the British Electricity Authority departs from conventional practice in power station structures in that precast reinforced concrete units have been employed for the columns and beams of the turbine house and switch house. These units are large and heavily loaded; the structure which they form is analogous in some respects to a conventional steel-framed structure.

THE British Electricity Authority has in recent years employed reinforced concrete for the structures of the turbine houses of new power stations on several occasions. Hams Hall "B," at Birmingham, is one example, and a second is that of Skelton Grange, near Leeds,* where a shell roof combined with portal frames was built. The most recent example, however, the Acton Lane "B" power station of the London Division, is unique in that precast elements have been used for the turbine house and switch house, the various columns and beams being cast at the basement level and then erected by two derricks without the use of scaffolding. The principal columns and beams are of massive proportions and are probably larger than any precast units used hitherto.

Acton Lane "B" Generating Station

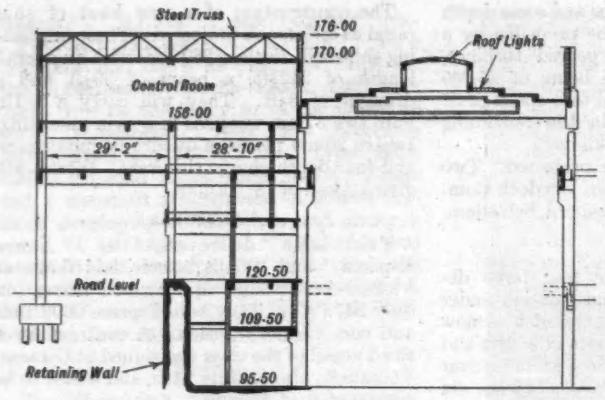
Before giving further details of the turbine and switch house structures we have included in this section some of the particulars of the new generating station.

The Acton Lane "B" station is intended to supersede the existing "A" station, which was first started up in 1899, and in which some of the existing plant dates from 1924. The existing station has an installed plant capacity of 158MW, which will be shut down in stages as the new station is brought into commission.

The new station, when completed, will house six 30MW turbo-alternators and nine boilers, each of 240,000 lb per hour maximum continuous rating. The steam conditions will be 600 lb per square inch at 850 deg. Fah., at the turbine stop valve, and the condenser vacuum 28·5in Hg. Generation will be at 11·6kV. The boilers are to be stoker fired. The station will be operated as a two-shift station and it is expected that a thermal efficiency of 25·5 per cent will be achieved.

The first section of the building now under construction will accommodate three turbo-alternators and five boilers, of which two turbo-alternators and three boilers are now on order. The first set is due for commissioning early in 1954 and the second set a year later. The boiler-house will be a steel-framed building. Three reinforced concrete chimneys, each serving three boiler units, will be supported on the boiler-house steelwork. The height of the chimneys will be 300ft above ground level. Three reinforced concrete cooling towers, each cooling 2·25 million g.p.h., and one existing tower of 1·5 million g.p.h. will serve the completed station; one tower is now nearly completed. The cooling towers will be provided with moisture eliminators to reduce

* See THE ENGINEER, October 28, 1949.



CROSS SECTION OF SWITCH HOUSE AND TURBINE HOUSE

the possibility of "carry over" nuisance to surrounding property.

Coal will be unloaded from rail for the first section by the existing wagon tipplers north of the canal and conveyed by the existing belts to the south side of the canal, from which point a new belt in a tunnel and an inclined belt will deliver to the new station bunkers. A further wagon tippler will be installed later. The coal store for the new station will be on the site of the existing station and will be increased in area as the existing wooden cooling towers are taken out of commission. Rail access to the site is by a new bridge from the existing sidings north of the canal.

The foundations of the new power station are of mass concrete, extending down into the blue clay under the columns and other heavily loaded points. The maximum load from any one column is 764 tons and the permissible bearing pressure on the mass concrete is limited to 30 tons per square foot. The general level of the basement is about 24ft below ground level and the area is surrounded by a reinforced concrete retaining wall 20ft deep, which carries the external columns of the switch house and boiler-house. Provision is made at the west end for building the second section of the power station in the future.

Precast Concrete Structure

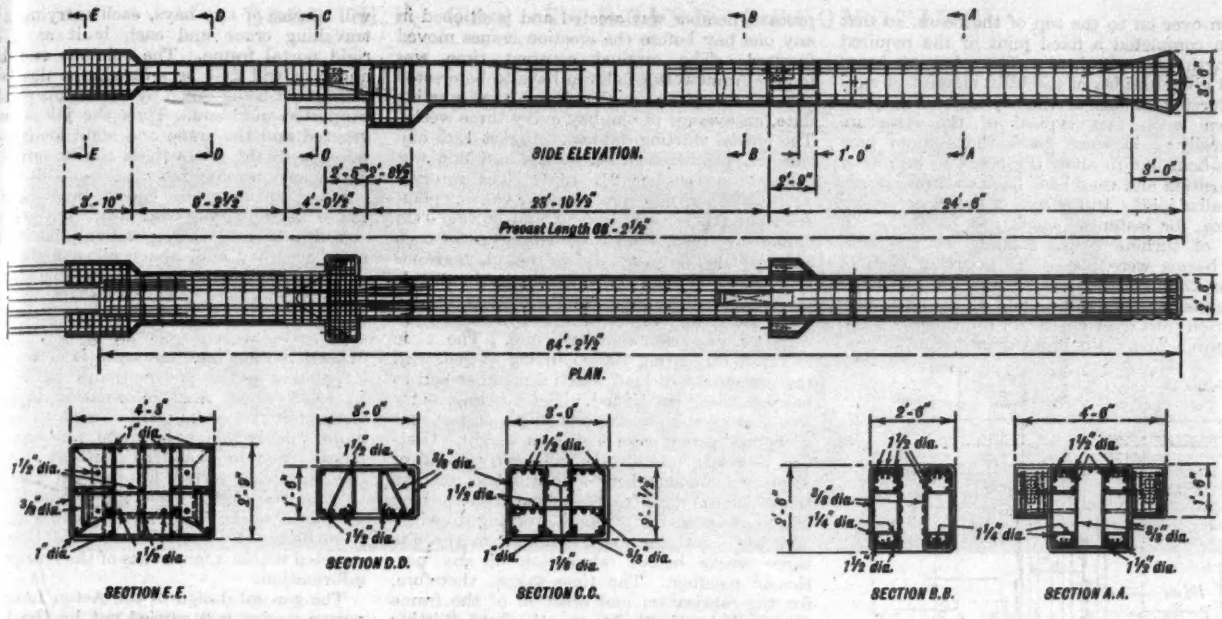
The turbine house consists of two rows of principal columns 63ft apart, the columns being spaced at 27ft centres. The columns in the south row will support the boiler-house steelwork, and will each carry a load of 360 tons from the boiler-house in addition to their own load from the turbine house. The roof is carried in a single span of 63ft across the columns by precast beams, whose under side is 61ft 3in from basement level. Crane beams, supported by brackets cast on to the columns, carry an electrically operated travelling crane 50ft above the basement, capable of lifting 70 tons. The generators will be founded 24ft above the basement and surrounded by an operating floor. The switch house is supported on the inner row of turbine house columns and, 30ft away, on another row of columns at corresponding centres of 27ft. This building has four storeys and is approximately 60ft high, although it has an additional storey (the control room) over certain areas. The switch house consists of ten bays of 27ft each and the turbine house likewise, with the addition of one bay of 25ft at the east end. The accompanying cross section through the switch house and turbine house shows the general arrangement of the columns and beams in these two buildings; the section is taken through the control room of the switch houses. The first photograph reproduced herewith also gives a good idea of the site, showing the retaining wall supporting the switch house columns, the turbine house structure and the two derricks. In the foreground the casting of columns and beams is in progress. The second photographic reproduction shows the turbine house from the other end with the 8ft 6in circulating water main to the cooling towers in the centre of the basement; the casting of beams and columns may be observed in the background.

The principal columns are 30in by 30in in section to crane level and 36in and 18in from there to roof level. They have a total precast length of 66ft and weigh about 30 tons each. Each column is made and hoisted in one piece, by one derrick. For handling, a collar is fixed round the brackets on the column at about the level of the crane beam. The main beams over the turbine house are also cast and lifted in one piece. They are each 64ft long, 6ft deep at the centre, 18in wide, weigh 26 tons, and are lifted on to the tops of the main columns into their true positions by both derricks. The crane beams are 4ft 6in deep, 18in wide and 26½ft long and weigh 12¼ tons. The switch house columns are somewhat smaller than those of the turbine house, but the same principles apply. The main floor beams in the switch house are 30ft long and weigh about 7¼ tons each.

As may well be imagined, a number of unusual problems, both in design and construction, had to be solved with this structure. The success of the method has, in fact, depended largely on close co-operation between the design office and the site staff, and the design has involved a consideration of erection and site conditions throughout all its stages. The resulting structure is analogous in many respects to a conventional steel-framed structure. It was not designed as a monolithic frame but as a number of simply supported beams and columns. Considerable care has been taken, however, to impart a degree of rigidity at the joints, which is necessary to lock them against any tendency to movement caused by the live loads of, for instance, the turbine house crane and wind forces. The joints are, therefore, similar in their function to the cleats normally used at the joints of steel structures.

ERECTION OF PRECAST CONCRETE STRUCTURAL FRAME

INTERIOR OF TURBINE HOUSE FRAME



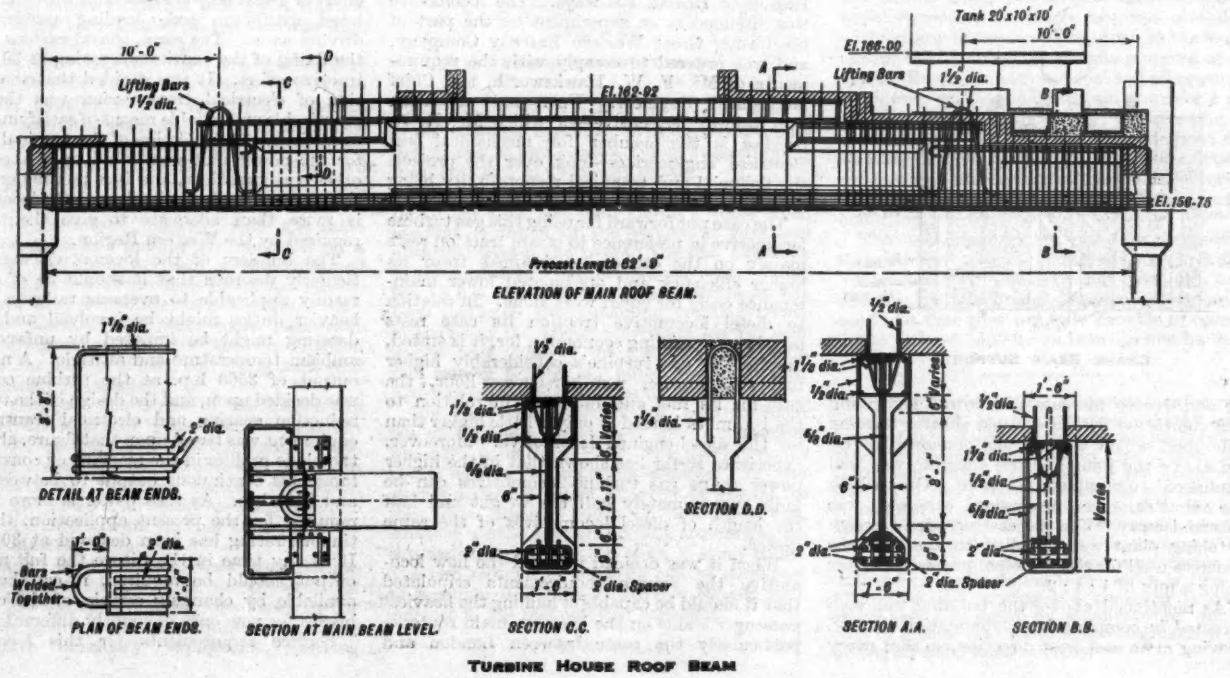
TYPICAL TURBINE HOUSE COLUMN

The first photographic illustration referred to above shows the two 30-ton derricks which travelled along each side of the turbine house as erection proceeded. The basement provided a convenient casting yard, but very careful planning of the work was necessary. The erection was started at the eastern end, with the various beams and columns positioned for casting so that they were available to the cranes to pick up and place where they were to be erected, after being in their moulds for sufficient time to permit adequate curing. The floor of the basement was thus progressively cleared to allow the derrick to move forward. The derrick did not move forward to erect a column until the previous bay had been completely erected. Generally the columns were cast with their feet close to their final position, to facilitate erection. Casting was carried out in timber moulds, especial care being necessary to keep the forms of the larger unit free from wind.

For the erection of each of the main columns a pit was left in the basement with a pin in the centre of it. A hole was left in the base of the column so that it would be located by dropping it on the pin. When thus located it was plumbed and held in position by four guys (as may be seen with the right-hand column in the foreground of the illustration on page 174). The base was then concreted up to the general level of the basement. When this concrete had set the column was sufficiently rigid to take any wind loading, &c., due to the framework of beams above it prior to grouting the joints. The various beams were rested on brackets or in slots so that no temporary stagings or props were necessary for erection. Measurements taken during a high wind with the structure in this condition revealed negligible movement. With the framework erected and trued into position, the joints and concrete floors are being cast in situ. The structure will be completed with brickwork cladding, the wind force being absorbed by 9in brick party walls built across the switch house at alternate column positions throughout the heights of the building.

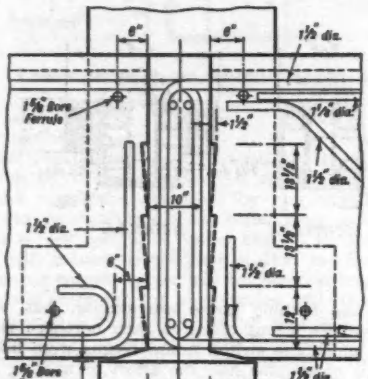
The drawings on this page show details of examples of the principal structural members. A turbine house column is shown; this column is one on the boiler-house side and takes the additional load from the boiler-house structure. The corresponding columns on the other side of the turbine house are similar, but were cast with a long chase on their northern sides, in which the switch house beams were fitted. This chase also had the effect of making the column slightly lighter, thus keeping its weight within the capacity of the derrick on that side, which lifted the turbine house columns at a greater reach than the other derrick, as it had to cover the area of the switch house as well as the north row of turbine house columns. The load on the column shown will be eccentric to its base, unless the load of the crane is acting on it. It will be seen that the reinforcing steel has therefore been placed asymmetrically.

The turbine house beam is reinforced with 2in diameter main bars, as may be observed. To obtain adequate bond for these large bars at the end of the beam, some of the bars were looped and welded as shown in the detail sketch. Reinforcement projecting from the top of the columns entered within the looped ends of the main bars projecting from the ends of the beams as the beams were lowered vertically into position. Additional lacing reinforcement was placed at this junction, splicing with the column reinforcement and



TURBINE HOUSE ROOF BEAM

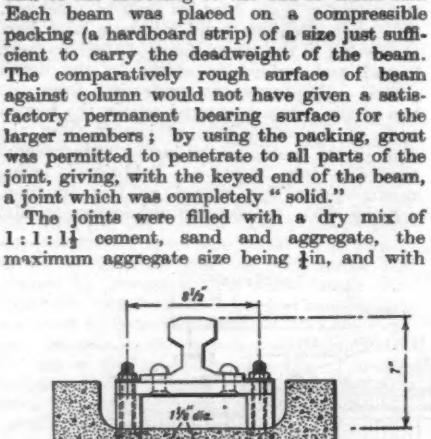
taken over on to the top of the beam, so that when completed a fixed joint of the required strength was obtained. The plan at beam level gives an idea of the total amount of steel reinforcing at one of these joints. The joint shown is in fact typical of the structure generally; in some cases the column bars were bent out to allow the beam to be placed in position and then bent back to form part of a similar joint. In the case of the switch house beams, for instance, which rest on the north row of turbine house columns at one end, the beams were placed by inserting each of them through the slot in the switch house columns, and then bringing them back into position into their chases on the turbine house column. The main beam drawing also shows



CRANE RAIL FIXING

the "Z"-shaped precast roof units and the raised central part of the roof, which is to be cast in situ with "Lenscrete" roof lights. A detail is also shown on this page of a typical beam support—in this case the crane beam—and of the fastening of the 112 lb crane rail. Each beam was placed on a compressible packing (a hardboard strip) of a size just sufficient to carry the deadweight of the beam. The comparatively rough surface of beam against column would not have given a satisfactory permanent bearing surface for the larger members; by using the packing, grout was permitted to penetrate to all parts of the joint, giving, with the keyed end of the beam, a joint which was completely "solid."

The joints were filled with a dry mix of 1 : 1 : 1½ cement, sand and aggregate, the maximum aggregate size being ¼in, and with



CRANE BEAM SUPPORTS

an additive to increase the flow. The filling was completed with a splayed shutter forming a hopper, which allowed the concrete to rise 3in above the joint and the concrete was well hammered to complete the joint. On striking the shutter, the projecting concrete was trimmed away. For the casting yard a weigh batching plant was installed on the site, the concrete used for the principal precast elements being a mix of 1 : 1 : 2.

As mentioned above, the building was constructed in complete bays, foundation to roof, moving in an east-west direction, so that every precast member was erected and positioned in any one bay before the erection cranes moved forward. The original contract time was for the framework of eleven bays to be erected within thirty-six weeks from the starting date, an average of one bay every three weeks. The official starting date was August 15th and the first precast member at the east end was erected on October 21, 1951. The interval was taken up by preliminary works, plant erection, fabricating, casting and curing. On January 3, 1952, eight complete bays had been erected (the date at which the photographs reproduced on page 174 were taken), the rate of erection on that date being one bay in five days, giving an average of one bay in about ten days or half the contract time. The time required for curing before lifting varied with the percentage of load which a member had to bear on being positioned. The deciding factor was that of the precast roof units, 50 per cent of whose loading were their own weight. Casting, however, was always sufficiently ahead of erecting for a member to be lifted in not less than fourteen days from the time of the placing of the concrete. In general, working drawings and bar schedules were required on the site three weeks before fabrication of any particular member. The time taken, therefore, for the fabrication and erection of the frame work will be about five months from starting date.

The weight of reinforcement involved in the structure is about 330 tons. An accurate estimate of the amount of structural steelwork which would be involved should the building have been so constructed (instead of in reinforced concrete) proved to be 1000 tons or three times as much.

At the present time one of the new cooling towers is also nearly completed. A workshop and stores building, also of precast reinforced concrete construction, is also to be built. It will consist of two bays, each carrying a light travelling crane and each built as a semi-rigid portal frame. The columns and beams and roof will first be erected, the deadweight of the roof being taken by the beams as simply supported members. Then the joints will be grouted and the crane and wind loads will be taken with the joints rigid, the structure then acting as a two-bay portal.

Being precast, an enormous saving was made in shuttering and formwork with, the consultants state, correspondingly better finish, more accuracy and, above all, a higher grade of concrete, than that obtainable by cast in situ methods. Therefore, it is stated, having due regard to the supply situation of such materials as steel and timber, this kind of construction uses less steel, is cheaper, uses less timber and is quicker than other methods. In cases where final information is delayed last minute revisions can be made to members more quickly and at a more advanced date before erection than in steelwork. In this particular case certain information with regard to some transformers was not available until a very late stage, but the supporting members were designed, detailed and were being constructed within a few weeks of the receipt of the information.

The general design of the Acton Lane "B" power station was carried out by the London Division of the British Electricity Authority. The contractors for the foundations, precast framework and in situ floors are Sir Robert McAlpine and Sons, Ltd., and the consulting engineers for the design of the precast work are Messrs. Brian Colquhoun and Partners. The general principles and practical details of the precast scheme were evolved jointly by the contractors and the consultants, the closest co-operation being maintained between their respective design departments at all stages of the work.

Gas Turbine Locomotive No. 18,100

No. I

A new gas turbine electric locomotive to be placed in service on the Western Region of British Railways is a 3000 h.p. unit designed and built in this country. It has a maximum tractive effort of 60,000 lb, with a continuous rating tractive effort of 30,000 lb, and is designed to haul 780-ton trains at speeds up to 90 miles an hour.

THE first gas turbine electric locomotive to be designed and built in this country has been completed by the Metropolitan-Vickers Electrical Company, Ltd., for the Western Region of British Railways. The locomotive was intended as an experiment on the part of the former Great Western Railway Company, and was ordered to comply with the requirements of Mr. F. W. Hawksworth, the Chief Mechanical Engineer. Upon nationalisation the Railway Executive—of which Mr. R. A. Riddles is the member for mechanical and electrical engineering—took over the project, the financial and technical responsibility being shared by British Railways and the makers.

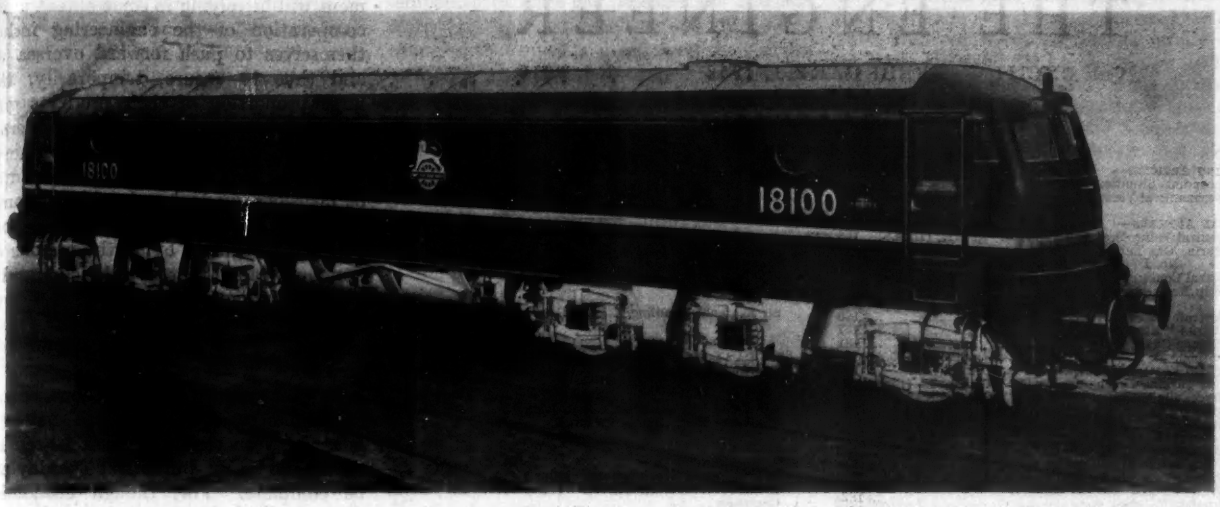
The case put forward for using this gas turbine locomotive in preference to steam traction rests mainly on the economies obtained from its higher efficiency and anticipated lower maintenance costs for equal work done. In relation to diesel locomotive traction its case rests largely on operating economies, for, it is stated, despite the gas turbine's considerably higher fuel consumption per horsepower-hour, the cost for its fuel and lubricant in relation to the ton-miles hauled is only a little higher than for the diesel-engined locomotive. Moreover, experience so far has shown that in the higher power range gas turbine locomotives can be built approximately half the weight and half the length of diesel locomotives of the same power.

When it was decided to build the new locomotive the service requirements stipulated that it should be capable of hauling the heaviest passenger trains on the Western main routes—particularly the route between London and Plymouth—at speeds of up to 90 m.p.h. To haul such trains up the heavy gradients, which are up to 1 in 36, it was necessary to have a locomotive with a maximum starting effort of about 60,000 lb—which with the stipulated maximum axle loading required six driving axles. The same considerations led to the fixing of the continuous rating at 30,000 lb tractive effort. It was decided that the adoption of electrical transmission was the only practicable and reliable means of satisfying these conditions. The selection of the nominal rating for the power unit was based upon these and other considerations, and it is pointed out that the power actually available with the locomotive is more than adequate to give the timings required by the Western Region.

The builders of the locomotive were particularly desirous that it should be of a type readily applicable to overseas railways where heavier duties might be involved and where derating might be imposed by unfavourable ambient temperature and altitude. A nominal output of 3500 h.p. at the turbine coupling was decided upon, and the design of the turbine, reduction gearing and electrical transmission equipment was based upon that figure, although the blade profiles in the machine as constructed limit this continuous output to between 3100 and 3200 h.p. As that power is more than is required for the present application, the continuous rating has been declared at 3000 h.p. If at any time in the future the full nominal output should be required, it can be made available by changing certain of the existing blades for new ones of slightly different profile.

Service requirements for this locomotive

3000 H.P. GAS TURBINE LOCOMOTIVE



also dictated other points in design, including a double bogie arrangement of running gear with the equivalent of swing bolster action for good riding up to 90 m.p.h. An oil-fired train heating boiler has also been installed to feed the steam heaters on the train. Automatic train control equipment as used on the Western Region is fitted as well as an automatic control scheme to bring the driving technique within the capacity of the regular staff of the railway without need for highly specialised training.

The principal dimensions of the locomotive, No. 18,100, as illustrated above, are as follows :

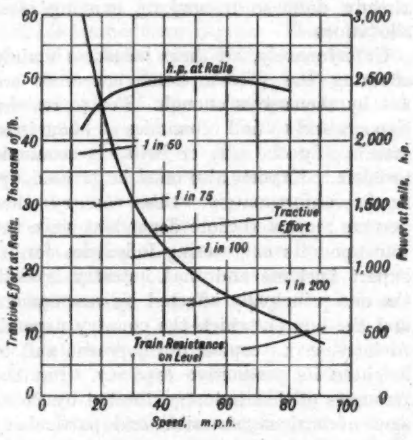
Length over buffers	66ft 9in
Bogie wheelbase	15ft
Bogie centres	37ft 6in
Total wheelbase	53ft
Body width	9ft
Height above rail	12ft 6in
Total weight	130 tons
Maximum tractive effort	60,000 lb
Continuous rating tractive effort	30,000 lb

The body structure of the locomotive, within which the power plant is totally enclosed, has a driving cab at each end. This body is carried on the two bogies by swing links which are resiliently attached by rubber universal joints to permit controlled swing bolster action and bogie pivoting without the use of actual bolsters, which would have needed more space than was available between the bogie frames and within the fixed wheelbase. The three axles of each bogie are each driven through a single reduction gear by a traction motor which is suspended on the axle and from a support on the bogie frame.

When delivering full load the gas turbine rotates at 7000 r.p.m. and drives three main traction generators at 1600 r.p.m. through single reduction gearing. In this reduction gear unit one of the two output shafts drives two main generators and the other drives a third main generator, the auxiliary generator and the exciter. The turbine, reduction gearing and group of generators, together with the main fuel and lubricant pumps, are mounted on a common bed-plate to form a self-contained power unit which is mounted in the locomotive on three support points on the main underframes. Each of the three main generators supplies current to two of the six traction motors, the motors of each pair being connected permanently in parallel.

The principal auxiliaries of the locomotive include the auxiliary generator, the exciter, main and auxiliary fuel and lubricant pumps, air blast coolers for the turbine and reduction gear lubricant, traction motor ventilation centrifugal blowers, air compressor and vacuum brake exhausters, train heating boiler, and the turbine starting battery.

It should be pointed out that from the gas turbine output of 3000 h.p. an allowance of about 150 h.p. provides for the losses in the reduction gearing and the requirements of the locomotive auxiliary equipment, leaving 2850 h.p. input to the traction generators. It is stated that over most of the speed range of the locomotive there is an electric transmission efficiency of about 86 per cent—corresponding to 2450 h.p. at the rails. We reproduce on this page a diagram showing the locomotive tractive effort and train resistance in relation to train speed, when hauling eighteen coaches weighing some 650 tons, which, with the locomotive, gives a train totalling some 780 tons. It will be seen from this diagram that the



PERFORMANCE CURVES

power available is sufficient to give such a train balancing speeds of 85 m.p.h. on the level and 41 and 23 m.p.h. respectively when climbing gradients of 1 in 100 and 1 in 50.

On test a turbine full-load thermal efficiency of 19 per cent has been shown ; thus, when account is taken of the reduction gear and electrical losses, the overall thermal efficiency of the locomotive becomes 16 per cent. When the 75 h.p. required for driving auxiliaries has been deducted the remaining traction power available at the wheels represents 15½ per cent of the heat value of the fuel consumed, or a fuel rate of 0·88 lb per horsepower-hour. At half-power this rate will rise to about 1·3 lb.

The fuel tank is designed to hold sufficient gas oil for the locomotive to haul a maximum tonnage train over the London–Plymouth route with a considerable reserve. It also carries a corresponding quantity of gas oil for the train heating boiler on the same run. Another section of the main tank accommodates the water supply for the train heating boiler. The two sections of the tank can be employed as a single fuel tank to give a 60 per cent increase in the fuel carrying capacity.

(To be continued)

Bristol "Hercules" Tests

THE inter-overhaul period of Bristol "Hercules 634" engines in "Viking" aircraft of Airwork, Ltd., has been extended from 1000 to 1200 hours with the approval of the Air Registration Board. The extension follows trial runs of 1200 hours between overhauls by four Airwork "Hercules 634" engines.

The announcement follows closely on a "Hercules 634" repeat type test, just completed at Bristol. The engine tested was built up from components which had been in service in engines operated by B.E.A. and Airwork, Ltd. The Bristol Aeroplane Company has a contract with both these companies for "Hercules" engine overhaul and it was a relatively simple matter to select a set of components, all of which had already reached reasonably long lives, and build them together into one engine. Most of the major components in the build of this engine had already completed over 3000 hours of air-line service and some had exceeded 4000 hours. It was thought that if a type test could be satisfactorily completed on such an engine it would give valuable evidence of the ability of engine components to give satisfactory performance for at least another 1000 or 2000 hours.

Testing began on October 15th and ended on November 16, 1951, the total running time of the engine being 143 hours. Apart from the usual servicing, the whole test was completed without any attention being given to the engine except the oil pump, which was removed at one stage. Engine powers and fuel and oil consumptions were within the limits laid down for a new engine. When stripped for examination on completion of the test, one cylinder head ring was found stuck to its groove and one master-rod gudgeon-pin bush was found to have moved very slightly, but everything else was in perfect condition.

The next stage in the process of extending the overhaul period of Airwork and B.E.A. "Hercules 634" engines has not yet been decided, but the Bristol Aeroplane Company is confident that they are fully capable of operating to at least 1500 hours between overhauls.

A 10IN SAW BENCH.—A pedestal rising top 10in saw-bench has recently been added to the range of light woodworking machines made by the Startrite Engineering Company, Ltd., Gads Hill, Gillingham, Kent. The body of the machine is built up of heavy sheet steel and the saw assembly is mounted on a rigid cast iron frame at the top. The saw spindle is driven at 2800 r.p.m. through vee belts and pulleys by a motor in the base of the pedestal. A tilting rip fence and a protractor are mounted on the elevating table, which is 19in by 17in. The ball bearing saw mounting is dust-sealed and, if required, an abrasive wheel can be used to replace the saw to adapt the machine for cutting off metal tubes and rods.

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THE ECONOMIC SITUATION

THE Government's energetic programme to alter the present serious economic situation of this country must very soon begin to affect the lives of everyone living here. Yet much of what Mr. Butler had to say last Tuesday in the House of Commons had little direct interest for engineers or for the engineering industries. The task of the Government in bringing the oversea trade of this country back into balance must be to encourage exports, to restrict imports, to restrict home demand and to prevent inflation. As contributions to bringing about those results Mr. Butler announced that imports of food and of various other products, such as clothing, furniture, carpets, shoes and toys, would be restricted by another £150 million over and above the £350 million announced in November. The foreign travel allowance is to be cut to £25; there are to be Health Service charges; the hire purchase of various goods is to be restricted; there is to be a saving of £22 million on purchases of tobacco this year; the cost of information services at home and abroad is to be cut by £1,200,000; civil service staffs are to be reduced by some 10,000 persons; and in the face of increases of wages and prices Government departmental expenditure is to be held down to that ruling last year, "a fall," to quote Mr. Butler, "in the proportion of the country's gross material product which the Government takes for its civil expenditure from about 15 per cent to about 13½ per cent. In addition—and here we come to matters of greater engineering interest—the supply of various goods made in this country to the home market is to be cut. The supply of cars and commercial vehicles is to be cut in comparison with last year by some 40 per cent and similar restrictions of supplies to the home market of such things as bicycles, washing machines, vacuum cleaners, sports goods, &c., are to be applied. Firms making such goods who cannot find markets abroad for their products may be severely affected. For Mr. Butler was ruthless in stating that "where goods cannot be exported it may be necessary to reduce output so that resources can be transferred to other products which can be sold overseas." The Government intends, it appears, to discriminate openly in steel allocations in favour of exporting firms. It has indeed already done so in making existing steel allocations.

Unfortunately, all these measures mainly affecting the private home consumer are not by themselves enough. For to restrict imports and to find economies at home is to attack only one side of Britain's economic problem. Exports also must be pressed up. Again unfortunately, this country has become more and more dependent since the war upon its engineering industries for its export business and that industry is both the one principally affected by rearmament and the one on which the country depends to increase its capital development and to heighten its productive capacity. But the resources of that industry, limited by shortages of various materials and particularly steel, are not adequate to meet all demands. In consequence and as, it is very much to be hoped, a temporary measure dictated by the extreme urgency of the economic situation, there has to be a restriction of capital development at home. "A tight control," said Mr. Butler, "will have to be kept on all types of building using steel which are not of fundamental importance to the national economy. Shops and offices will be particularly affected. . . . At the same time work on some industrial projects of high long-term value to our balance of payments will have to be slowed down or stopped altogether and the start of a large number of similar new projects will have to be postponed." Only building work for defence and for the fuel and power industries seems likely to be unaffected. Furthermore, it is the Government's objective to reduce total home deliveries of plant, machinery and vehicles by some £150 to £200 million, an average cut of "no less than one-sixth of actual supplies in 1950." In achieving that objective—one that obviously must severely affect the rate of increase of productive capacity in this country—the Government will be relying to some extent upon the co-operation of the engineering industries themselves to push forward oversea orders and thus to ensure, temporarily, that a large proportion of their products goes to export. All these actions and others that we have not had space to mention here are, of course, being taken within the framework of decisions made by the whole Commonwealth at the recent conference in London. But it is recognised by all the nations of the Commonwealth that restrictions and cuts are only palliatives and that only development of the great resources at the command of the whole Commonwealth can provide the true remedy.

It is an unfortunate consequence of our traditional stocktaking at the end of each financial year that any such statement as that made by Mr. Butler last Tuesday cannot be complete. For, though economies in Government expenditure and various other changes mentioned by Mr. Butler may have a deflationary effect, it is obvious enough that imports cannot be cut by £500 million and home manufactured supplies to the home market be restricted without producing strong inflationary consequences. Those consequences can only be averted by Budgetary means. It is therefore welcome news that the date of presentation of the Budget is to be brought forward to March 4th. Nevertheless, the debate upon the economic situation in the House, which opens as we go to press, is bound to be hampered by lack of knowledge of the fiscal measures that Mr. Butler no doubt has in mind to meet the situation which will be created at home when the measures he outlined last Tuesday become effective. Before it can learn to the full what are to be the consequences of the Government's laudable intention to make sterling a strong, stable and convertible world currency the country needs to hear what changes in taxation and in fiscal policy will be entailed. The outlook in that respect cannot be anything but gloomy.

AERONAUTICAL VIEWS ON MARINE PROPULSION

ENGINEERS have far more experience of the use of gas turbines in the air than on the ground or at sea. As a very natural consequence designers of aero-engines feel that their acquired knowledge and experience of gas turbines should be of value in the development of industrial and marine plants. Indeed, in private, if not in public, they often prove very critical of gas turbine plants designed upon the basis of existing steam turbine practice. But never before has the heavy engineering industry found it desirable to turn so directly to the aircraft industry for advice. It is true that the motor-car engine benefited to some extent from aeronautical advances and that the development of aerodynamic theory assisted steam turbine designers. But the connection there and in several other fields was not very direct and aeronautical engineers were regarded, until the advent of the gas turbine, as working in a specialised field of their own, encountering problems usually very different from those to be met in more ordinary engineering practice. Now, however, the influence of aircraft engine manufacturing

firms, besides that of research and development organisations such as Power Jets, Ltd., the successor of Whittle's own firm, is being increasingly felt in firms building land and marine gas turbines, and more than one designer of such plant acquired experience mainly through the study of advances in the techniques of aeronautical design. A fertile cross-link between two hitherto widely separated technical fields is being forged.

It is not to be supposed that engineers with widely different experience in aeronautics and in marine matters can be brought together without a resounding clash of opinion. But there can be no doubt of the value to the heavy engineering industry of the stimulation to thought created by aeronautical criticism. Its value was well illustrated last Friday at the Institution of Mechanical Engineers, when Mr. Holmes Fletcher, chief designer, Marine Division, of Rolls-Royce, Ltd., had the temerity to present a paper on "The Marine Gas Turbine from the Viewpoint of an Aeronautical Engineer." The paper, of which we print an abstract elsewhere, included particulars of a marine gas turbine of 4000 s.h.p., weighing only 6 to 10 tons, of which parts would need to be replaced, as an item of regular maintenance, after every 10,000 hours or so of running. As will be seen from the report of the discussion that we print in this issue, there was plenty of criticism! In fact, the author remarked in his reply that his audience appeared to regard his turbine as a fine thing—if only he would change the compressors, have a single combustion chamber, a different intercooler, a different heat exchanger, and so on! But he was not dismayed; nor was there reason for him to be dismayed by the criticism. The interest aroused by the paper was quite sufficient justification for its presentation, and, if the discussion served no other purpose, it did bring out clearly what are the differences between air and marine designs. The aero-engine designer seeks to make a compact, symmetrical, machine of small frontal area and to save weight, because weight in an aircraft is so very well worth saving. In doing so he is prepared to indulge in high rotor speeds and high gas speeds, and to compensate for the ducting losses involved by using high gas temperatures, thereby limiting the life of the engine. The desiderata for a naval marine engine are not so very different. For naval engines spend most of their working lives at cruising powers; and relatively short lives at full power and high gas temperatures can be tolerated. In fact, Commander Trewby saw the main advantages of the naval gas turbine as reduction in weight and space for a given endurance, reliability, easy maintenance, rapid starting and flexibility in operation. He felt that those advantages might never be realised if the design of naval gas turbines was based on principles established from long experience with steam plants. But the desiderata for the engines of a merchant ship are different. The mechantman operates for most of its life at or near maximum power. Its engines need to be economical and to operate for long periods between overhauls. Large sums of money are likely to be lost through any delay so that reliability is essential, and so, too, are ease of maintenance and infrequency of overhaul. There is less need for rapid starting. To realise economy in operation and to combine it with the reliability that comes from running at lower maximum temperatures large gas passages are needed. Moreover, the intercoolers and heat exchangers that must be fitted must themselves be easily maintained—a point that led to adverse criticism of the author's small-tube exchanger, notwithstanding its very high efficiency. That there is a benefit to be found in reduced size and weight is undoubted. But, if it is in conflict with other factors, that benefit is quite outweighed by them. Nor can original cost be left out of account. For a light and highly stressed design might well prove costly to manufacture.

The marine engineer has become accustomed to think of an engine as capable of outlasting the ship in which it is installed. Yet, as one speaker remarked in the discussion, "It is not necessarily a virtue in a mechanism that it shall outlast obsolescence!" Moreover, it may pertinently be asked whether longevity is necessarily lessened by using light structures and higher component loadings; and, even if it is lessened in certain parts exposed, for instance, to high temperatures, whether "replacement" of such parts is really so very different to the regular "maintenance" to which marine engineers are accustomed? Certainly the requirements of a marine engine are not so different from those of an aero-engine that a great deal cannot be learnt from aeronautical experience. As Dr. Bowden remarked, "the gas turbine is a low-pressure engine and a variable-temperature engine. Those factors demand a light symmetrical construction, and its accepted design will conform more closely to aircraft than to present marine and industrial conceptions." No doubt there will be conservatism to overcome. The expression of conservatism was not absent from the discussion. Only satisfactory experience at sea can overcome it. Mr. Welsh was, of course, right in saying shipowners are not flocking to buy marine gas turbines because "it is not yet possible to burn heavy oil with consistent success; reversing means have not yet been developed commercially; the reliability is not yet sufficiently established for single-screw, single-engine ships." But unless shipowners take the plunge the necessary experience cannot be gained. It is therefore encouraging to find that in this issue we are able to refer to the completion of the first voyage of the marine gas turbine that has been installed in the M.V. "Auris." Shipowners, the world over, will await with interest the outcome of that experiment in marine gas turbine propulsion, and, we hope, many others to follow it.

Obituary

SIR REGINALD STRADLING, C.B., F.R.S.

We regret to have to record the death of Sir Reginald Stradling, C.B., M.I.C.E., F.R.S., which occurred, suddenly, at Shrivenham, Wiltshire, on Saturday last January 26th. Sir Reginald, who was in his sixty-first year, had been Dean of the Military College of Science, Shrivenham, since 1949.

Reginald Edward Stradling was born at Bristol on May 12, 1891, and received his general education at the Merchant Venturers' School and Bristol Grammar School. He studied engineering at Bristol University—which later conferred upon him the degree of D.Sc.—and then, between 1912 and 1914, received practical training under Mr. A. P. I. Cotterell, M.I.C.E. Subsequently, Reginald Stradling extended his practical experience with Messrs. Bradshaw, Gass and Hope, civil engineers and architects, of Bolton, with the Midland Counties Reinforced Concrete Company, and with Mr. Harry Jackson, M.I.C.E., who was engaged on various water supply and sewage disposal schemes. In the first world war he held a commission in the Royal Engineers, was awarded the Military Cross, and was twice mentioned in dispatches.

In 1918 Sir Reginald went to the University of Birmingham as a lecturer in civil engineering, and during his four years in that appointment frequently assisted Professor F. C. Lea in private consulting work on structural problems. He then became head of the Department of Civil Engineering, Architecture and Building at the Bradford Technical College, where he remained until 1924. In that year Sir Reginald was

SIR REGINALD STRADLING

appointed Director of the Building Research Station set up by the Department of Scientific and Industrial Research. During his fifteen years in that office the work of the station was considerably extended and many important experiments on building construction and road work were carried out under his direction. When war broke out in 1939 Sir Reginald became chief adviser on research and experiments in the Ministry of Home Security, in which office he served until 1944, when the Ministry of Works appointed him chief scientific adviser. His many tasks in the years that followed included researches and experiments concerned with the Government's housing schemes. For a time, at the end of the war, Sir Reginald also acted as an adviser in the civil defence section of the Home Office. In 1949, on the death of Dr. C. H. Lander, Sir Reginald was appointed Dean of the Military College of Science.

Sir Reginald's knighthood was conferred in 1945, he having previously received the honour of C.B. in 1934. He became a member of the Institution of Civil Engineers in 1917 and a Fellow of the Royal Society in 1943. In 1942 Sir Reginald was awarded, by the Council of the Institution of

Civil Engineers, the James Alfred Ewing Medal "for specially meritorious contributions to the science of engineering in the field of research." Sir Reginald was also an Honorary Associate of the Royal Institute of British Architects and an associate member of the American Society of Civil Engineers. In 1947 he was the recipient of the America Medal for Merit, an award which was made in recognition of experimental work concerned with the explosive effects of the atomic bomb.

Literature

The Mechanism of the Watch. By Sir James Swinburne, M.I.C.E., F.R.S. London: The N.A.G. Press, Ltd., 226, Latymer Court, Hammersmith, W.6. Price 10s. 6d.

It is usually interesting to read a technical work which is written by someone who, though conversant with some branch of science that is allied to that discussed, is able to take an independent view of the matter, and is not prejudiced, consciously or unconsciously, by the accepted outlook and tradition of those closely concerned with highly specialised aspects.

The Mechanism of the Watch is a book of this kind, for its author, Sir James Swinburne, President of the Institution of Electrical Engineers as long ago as 1902, has made a hobby, since his retirement, of the study of watches and their mechanism. For this reason, his approach to horology is one that avoids any easy toleration of the long-accepted standards of the ancient craft.

Instead of acquiescing in most approved matters of theory and practice, Sir James sets out—often controversially—to ask "why," and it is surprising how often his questions reveal points on which the best authorities are not clear, or even disagree amongst themselves. In many ways, this is good, in that it stimulates discussion and research, but it must be confessed that some of the suggestions made in the book do not seem to this reviewer to be any more effective, as solutions to the problems of watch construction, than those orthodox ones that the author calls into question.

After a chapter on the centimetre-gramme-second system of measurement, which seeks to make this system clear, and, incidentally, makes the author's opinion of the various forms of measurement in general use very clear indeed, the work deals with all the important components of the watch in orderly sequence, beginning with the mainspring and terminating with the adjustment of the escapement. The fourteen chapters making up the book contain a great deal that is interesting, in that it is a record of patient experimental work. But there is also much that is highly controversial. The author, however, is, no doubt, well aware that some of his views are unlikely to be favourably received by horologists who have gained their experience along more approved lines.

An instance is to be found in the chapter on mainsprings, where Sir James appears to be at variance with most horologists as to the proportional relationship between the spring and its barrel, and to regard "clustering" as one of the most serious inherent faults of a mainspring. That it is undesirable seems agreed, though it probably occurs with every mainspring. Yet the modern commercial spring has a far more even and reliable power output than this chapter would seem to suggest as likely.

In the chapter on the train, the same entertaining, if intrepid, tendency to disagree with previous authorities is evident, particularly in matters connected with tooth form, and on the theory of "engaging" and "disengaging" friction. The author may have certain experimental data to support his views, but the weight of recorded technical experience seems against him, and it does seem rather relevant that the disproportionately heavy wear incurred by low numbered pinions when fitted to clocks and watches does not tend to bear his theories out. It is interesting that, at the end of the chapter, it is admitted that the efficiency of the train is higher than was expected. It is quoted as 85 to 90 per cent, which seems remarkably good.

One of the more unorthodox of the author's conclusions is that jewels are "quite valueless," except for the balance pivots, pallets, and barrel and centre pivots! He does concede that they may be "useful in virtue of their durability," which one would have thought was ample reason for their use in a watch, but he seems quite unconvinced that they serve much other use on train and escapement pivots. The reviewer would like to suggest that the author tries the experiment of taking a modern platform lever timepiece, whose escapement has seven jewels, and having jewel bearings fitted to the escape and lever pivots. The consequent increase in the liveliness of action is usually most notable, and as there is no more power available from the mainspring after the change has been made, the increase in the arc of the balance must come from a reduction in friction. The conclusions here seem self-evident.

In his discussion of escapement details, Sir James again sets his own course. One must admire his research work. But at the same time, his conclusions that the teeth of the escape wheel are often out of contact with the impulse faces of the pallet stones when the balance arc is large and only come into touch towards the last corner, are not the results to be observed when one watches a slow-motion film recently made by a leading British firm of clockmakers. One of the objects of the film was to study this very point, with the observations taken at normal operating speed, and the result shows the escape wheel lagging slightly from inertia, but making far better contact with its pallet than Sir James seems to suggest that it can.

The section on hairsprings is interesting, and seems to suggest that the author has centred most of his research and investigations on problems connected with this component. At the same time, it is difficult to agree with his statement that the inventor of the "overcoil" may have made his spring that way "because it looked nice." Abraham Louis Breguet was a horologist of such outstanding ability, and had such a wide vision, that this writer regards it as unlikely that he made such a revolutionary change in hairspring construction without knowing the implications. He may not have realised all the developments and technical improvements that would follow his work, for inventors rarely do know to the full how well they have built, but the true value of the design can hardly have escaped him.

The rest of this controversial book has sections devoted to considerations affecting the balance, and to such factors as magnetism, oil, pivot friction and adjustment. Each aspect has clearly received extensive attention from the author, and for this reason alone is worth reading. His final sentence, which states that "The watch is much more mysterious than the clock and, to many, much more engrossing as a study," may well invite challenge, for research into the behaviour of clocks is a long way from finality, and neither, as machines, are any more mysterious than natural laws and the limitations of our scientific observations, make them.

Even though horologists are likely to reject many of the author's conclusions as unsound they will nevertheless be grateful to him for challenging accepted practice and making them consider again whether, in fact, long accepted standards are sound ones.

Short Notices

Standard Methods of Analysis of Iron, Steel and Ferro-Alloys. As used in the laboratories of the United Steel Companies, Ltd. 1951. Sheffield: The United Steel Companies, Ltd. Price 17s. 6d.—This revised edition of a well-known book has been produced by the co-operative efforts of chemists in the Central Research Laboratories of the United Steel Companies and in the laboratories of the associated steel works. Analytical methods which represent the standard practice of these laboratories are recorded. In each case principle, procedure and reagents required are described in detail, while the notes give information about interferences from the presence of other chemical elements or errors likely to be introduced by departure from standard conditions. Rapid methods, often found useful for control purposes in the works, are not included. The methods are selected for their accuracy and reliability, and a large number of them have remained almost unchanged over a long period; but full advantage has been taken of the organised research on analytical methods which has been in progress of late years under the auspices of B.I.S.R.A. Recent advances incorporated in the new edition are sections on absorptiometric methods and the use of the Spekker, polarographic methods for estimating copper and lead in steel, mercury cathode separations and a colorimetric method for determining the small amounts of boron found in boron-treated steels.

The book is a valuable contribution to the work of the metallurgical chemist, and should be available for reference in all laboratories dealing with the analysis of iron and steel.

A Multi-Gauging Exhibition

In order to demonstrate to industry the contribution which multi-gauging equipment and techniques can make to the rearmament programme, the Ministry of Supply's Directorate of Cutting Tools and Gauges held a two-day exhibition in London on Tuesday and Wednesday last, January 29th and 30th. This exhibition was held at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, each day, from 10 a.m. to 5.30 p.m. It was officially opened by Mr. S. W. Rawson, Director-General of Machine Tools of the Ministry of Supply, and invitations to attend were sent to Government engineers and contractors concerned with the rearmament programme. In the exhibition there were shown about twenty multi-gauging machines, with which it was demonstrated how multi-gauging can save time and labour when compared with many orthodox manual gauging systems. One machine, built up of units each gauging at one station, gauged twenty-two stations on a gas turbine blade simultaneously. Another electronic machine was able to gauge and grade ball and roller bearings at a rate of 10,000 per hour and can grade to an accuracy of 0·0000056in. In addition to demonstrations of recent advances in gauging techniques, the exhibition programme included a lecture on "Multi-Gauging and its Contribution to the Rearmament Programme," by Mr. J. Loxham, at 11.30 a.m. each day. These lectures were accompanied by a film on the subject of multi-gauging.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

AMERICAN DIESEL-ELECTRIC LOCOMOTIVE FOR AUSTRALIA

SIR,—The following item, taken from your issue of December 7th, would appear to be somewhat out of place from the point of exactitude although helping to explain the meteoric rise of the diesel-electric locomotive, particularly in areas of low "consumer resistance" such as the U.S. and Australia. I quote the relevant extracts from a paragraph headed "American Diesel-Electric Locomotives for Australia":—

"Officials . . . participated in ceremonies at Port Pirie, S.A., marking the opening of new, speedier transcontinental services in Australia due to the use of the new locomotive (which) will serve a train of the Commonwealth Railways on the Australian Transcontinental Railway from Port Augusta to Kalgoorlie and is expected to cut 20 hours off the previous three-day schedule for the 1051-mile run."

The facts are plain enough. Australia has no Transcontinental Railway, no Transcontinental Express. The best it has ever managed to achieve in that direction is a standard-gauge link between the western extremity of the South Australian broad gauge and the eastern end of the West Australian 3ft 6in, on which a bi- or tri-weekly train runs to connect up with the local overnight trains at either end, the timing of the so-called "Trans," train being made to suit those local connections. That fact is important. Once this connection has been made in minimum time, further speed is pointless, and that was the position which had been reached before the war.

The line now runs from Port Pirie (not Port Augusta) and the distance between those points is 1108 miles. It is to all intents and purposes dead straight and dead flat and is laid with well-ballasted 80 lb rails. Not even an Australian administration using camels could occupy three days in covering that distance and, of course, none ever did. The original schedule allowed two. About 1938 the old (1891) Beyer Peacock engines were replaced by a N.S.W. pattern machine of slightly less unsuitable type, two short sections of line were built and the trip was cut to one day. A traveller from Melbourne who had been compelled to make four changes of train, changing gauge three times in the process, could now reach Perth with two changes of train only and in a day less than formerly.

That schedule, which was in use till well into the war, has now been forgotten and its reintroduction has produced the results commented upon above. It is a great pity that the Americans do not produce and glamorise some method of overcoming breaks of gauge because, until they do, it is quite obvious that there will be no worthwhile improvement on that pre-war timing.

L. IRVINE-BROWN

Singapore, January 16th.

[Readers may like to refer to an article in our issue of September 22, 1950 (page 282) by G. H. Paulin, recording his experience of a journey on the railway concerned. The railway, it is true, is not called the Transcontinental. It is known as the Trans-Australian Railway. At the time of Mr. Paulin's post-war experience trains left Perth on Mondays, Wednesdays and Fridays at 8.10 p.m., arriving at Adelaide (via the Kalgoorlie-Port Pirie stretch) at 1.15 p.m. on Thursdays, Saturdays and Mondays. The total distance is 1622 miles with change of trains and gauge at Kalgoorlie and Port Pirie Junction. Over much of the distance—particularly on the Trans-Australian section—the water is of bad quality, so that a diesel-electric locomotive has at least one advantage over steamers for use on that railway.—Ed., THE E.]

THE RETURN OF THE NATIVE

SIR,—In the penultimate paragraph of the last letter from Mr. Livesay, which you published under the above heading in THE ENGINEER of November 9, 1951, he accuses me of being "too much inclined to indulge in hyperbole" because I claimed to have been "coated from head to foot with soot" when I was once travelling behind a 2-8-2 American-built, oil-fired locomotive on the French National Railways.

Perhaps after inspecting the enclosed photograph, originally published in the *Railway Magazine* for December, 1951, showing the down "Blue Train" passing Eze near Nice on July 6, 1951, photograph for which I am indebted to Mr. J. F. Henton, of Nottingham, Mr. Livesay may agree that American-built oil-fired locomotives do occasionally emit smoke. He may even further agree that this smoke is liable to enter the wide-open windows of the compartments of the train as it entered mine when I travelled in the very hot summer of 1947 on a night train hauled by such an engine, so that there was no necessity for me to travel (not "ride") on the roof as Mr. Livesay alleges, in order to become as filthy as I did on that particular occasion.

On the other hand, I have recently seen, at Lyon-Perrache station, the American locomotive from the (Marseilles) Blancarde Depot, just off the northbound Marseilles-Paris day express, which merely emitted a sort of blueish smoke comparable to the exhaust of a motor-car running on a rich petrol (gas) mixture, so that for my part I am quite prepared to agree that it should be possible to run these locomotives free from such smoke nuisance.

I could not help but wonder whether any carbon monoxide was present in such blue smoke and if so how its effect on tunnel maintenance gangs compares with the effect of smoke emitted by coal-fired engines.

As for Mr. Livesay's injunction in the last paragraph of his letter, "for me to sit in silence," I considered that as it lacked your official sanction, I could safely ignore it in order to vindicate my "hyperbole."

C. CARTY

London, W.C.1, January 24th.

THE BLUE TRAIN PASSING EZE, NEAR NICE

Butane Gas

ON Tuesday, January 22nd, the coal gas making plant at Whitland, Carmarthenshire was closed down and all gas consumers at Whitland were supplied with butane/air mixture. That form of supply is now to be permanently continued at Whitland. Supplies of liquid butane in high-pressure containers are now stored at the Whitland Works. They are delivered from the Llandarcy refinery of the Anglo-Iranian Oil Company. Two alternative plants for making the butane/air mixture have been installed; the one, a Mallet plant, imported from France, is the plant now primarily used. This plant employs two blowers, one for butane and one for air with a proportioning device to ensure a constant and correct mixture of butane vapour with air. The proportions in the mixture are in the region of three parts of air to one part of butane vapour. In cold weather the storage containers feeding the Mallet plant with the butane vapour are specially heated to ensure vaporisation of the liquid, neat butane being employed as a source of heat for the purpose. The other plant installed is a "Gasair" plant imported from the U.S.A. It operates on the venturi principle, whereby butane vapour under pressure aspirates the required amount of air to give a resultant gas mixture in order to ensure a correct mixture of butane vapour and air. This plant involves the use of a liquid butane vaporiser which is heated by neat butane. The Mallet plant is housed in a small building specially erected on the works site, and the American "Gasair" plant is a self-contained unit standing in the open. Both of these alternative methods for the production of butane/air mixture have been installed specially at Whitland to enable full tests to be made of the alternative efficiencies and advantages of each method of manufacture. When sufficient experience has been gained a decision will be made as to which of the two alternative forms will be installed at any future undertaking which may be converted to this method of gas supply.

C. M. HILL AND CO. (ENGINEERS), Ltd., 44-5, Tower Hill, London, E.C.3, has been appointed agent in this country for Soc. Anonyme Trains de Roues du Centre, Belgium.

Hydraulic Models of the River Thames

Two hydraulic scale models of the River Thames have recently been built by the Port of London Authority, a pilot model and a main model, with horizontal scales of 1 : 3000 *and* 1 : 600, *respectively. They will be used primarily to study problems of silting in the lower part of the estuary.*

A LARGE-SCALE hydraulic model of the River Thames has recently been constructed by the Port of London Authority at the Royal Victoria Dock. The study of certain aspects of the river's behaviour is being assisted by the model, in which the flow patterns, the movement of bed material and the behaviour of silt can be studied. To determine the most suitable location and orientation for the seaward limit and the tide generator in the model, appropriate experiments were carried out with a smaller pilot model. Although this pilot model was not designed to solve directly any of the problems before the investigation, some useful information has been obtained from it about the flow in the river before the formation of a dredged channel, which will enable valuable comparisons to be made with the characteristics of flow at the present time. In the future, some experiments in the Thames model will probably be duplicated in the pilot model and at a later date minor problems in those parts of the outer estuary which are not included in the Thames model may be investigated in the pilot model.

The models are intended primarily for the study of dredging problems in the river. Each year the authority has to remove nearly 3 million cubic yards of silt from the docks and rivers. The first problem which will be investigated with the model, therefore, is the reduction of silt in Tilbury Tidal Basin. The removal of this silt now costs the authority £75,000 per annum. The second problem is the improvement of the channel through Halfway Reach, Barking, and Gallions Reach to the King George V entrance to the Royal Docks, and the third problem is the reduction of silting in the Royal Docks themselves.

With the help of the London County Council an investigation has also been started by the Water Pollution Research Laboratory into other conditions in the estuary. The authority has built a laboratory at Tilbury and provides a 72ft long motor launch for taking readings on the river. The Thames model will also be utilised when required to determine the periods of retention in the river of liquids discharged at various places and states of the tide. When Sir Joseph Bazalgette, in 1874, built the London sewerage system to remedy the polluted state of the river, it was confidently stated that if the outfall at Barking discharged on the falling tide the sewage effluent would leave London never to return. It is now known that discharges to the river travel up and down the channel, only slowly progressing towards the sea; in addition, the Barking and Crossness outfalls flow continuously day and night. The aim of the authority is to raise the standard of cleanliness of the river until it is able to purify the discharges made to it during their slow progress to the sea.

Work on the models is being carried out under the direction of Sir Claude Inglis, Director of the Hydraulic Research Organisation of the D.S.I.R. Some of the main dimensions and characteristics are given in the accompanying table.

	Main model	Pilot model
Horizontal linear scale	1 : 600	1 : 3000
Vertical linear scale ...	1 : 60	1 : 120
Vertical exaggeration	10	25
Time scale	1 : 77·46	1 : 273·8
Tidal period (12 hours 25 minutes)	9 min 36·3 sec	2 min 43 sec
Discharge scale	1 : 278,850	1 : 3,943,000

The method of tide generation is similar on both models, and is by means of reduced air pressure created by a turbo-exhauster in a pneumatic displacer. The tides to be reproduced are drawn on a roll of paper in the form of a black and white graph: this graph is scanned by an electronic follower, which controls the air pressure in the displacer and hence the water level in the model. The apparatus was designed and constructed by the Hydraulic Research Station.

The main model has been moulded to represent the river as it is shown on the P.L.A. surveys, ranging in date from 1939 to 1949. Where the slopes are of 40 deg. or less, the moulding has been done in a natural silica sand with a mean diameter of about 0·20mm. Where the slopes exceed 40 deg., moulding has been done in cement mortar. The labyrinths at the upstream end have been constructed wholly in cement mortar.

The seaward limit of the model is on a line running N.12½ deg. E. and passing 600ft east of Southend pierhead. The estuary at this point is about 4½ miles in width. The model is moulded as far upstream as Westminster Bridge. The tidal prism between this point and the tidal limit at Teddington Weir is accommodated in a labyrinth. Measuring along the river channel, the principal lengths are :—

	Prototype	Model
Southend (model limit) to Westminster Bridge	45·17 miles	397·8ft
Westminster Bridge to Teddington weir ...	16·72 miles	148·4ft (labyrinth)
Southend (model limit) to Teddington Weir	61·89 miles	546·2ft (including labyrinth)

In the first experiments the pilot model was moulded to the survey of the river made in 1830–34 by Commander Bullock, R.N. The model has now been remoulded to P.L.A. surveys, ranging in date from 1939 to 1949. Where the slopes are of 40 deg. or less, the moulding of the Thames has been done in washed quartz sand with a mean diameter of 0·17mm. Where the slopes exceed 40 deg., cement mortar has been used. The River Medway, which is included in the pilot model, has been moulded entirely in cement mortar, as it is thought that only minor changes have occurred there in recent years. These changes would have no bearing on the investigation and would not materially affect the flow pattern of the Thames estuary.

The seaward limit of the pilot model is approximately on the limit of the P.L.A. It is the line passing through the Great Nore Towers, joining Havengore Point in Essex and Hens Brook (near Eastchurch) in Kent. The estuary at this section is about 10 miles in width. The upstream limit is Blackfriars Bridge. The tidal prism between Blackfriars Bridge and the tidal limit at Teddington Weir is accommodated in a labyrinth. The River Medway is moulded upstream as far as Rochester, and a labyrinth contains the tidal prism between this section and the tidal limit at Allington Lock. The accompanying illustrations show the main and pilot models; the representation of the Medway may be observed in the left-hand background of the illustration of the pilot model, with Southend pier on the right; a velocity meter may be observed spanning the river. The illustration of the main model shows Tilbury docks and landing stage in the right foreground and Gravesend on the left.

PART OF MAIN MODEL LOOKING UPSTREAM

Aims of the Investigations

Among the many problems before the Port of London Authority which it is proposed to investigate with the aid of models, the most important are those aimed to reduce silting and the consequent expensive dredging: (*a*) in the tidal basin at Tilbury Docks; (*b*) in the Royal Docks, and (*c*) in the three reaches of the river immediately downstream of the Royal Docks (Gallions Reach, Barking Reach and Halfway Reach—known collectively as "The Mud Reaches"). The maintenance dredging in the river (excluding the docks) is now approximately 1,220,000 cubic yards per annum, and about 79 per cent of this total is removed from the Mud Reaches and lower Gravesend Reach. The maintenance dredging in Tilbury Basin amounts to about 400,000 cubic yards per annum and in the Royal Docks to about 380,000 cubic yards per annum. The total for these three areas alone is therefore approximately 2,000,000 cubic yards per annum. The total annual expenditure by the

authority on dredging lies between £400,000 and £500,000.

In considering the work to be done with the model, the authority considers, it is important to emphasise the fact that hydraulic models do not provide direct answers to the complex problems of silting. It was once thought—and the opinion still seems to be widespread—that if a tidal model were to be moulded in suitable material to a survey of a certain date and run for a number of model "years," the model would then show on inspection the conditions to be expected in the prototype after the equivalent number of actual years. In fact, the conditions in the prototype and the model are too complex, and some aspects of the relationship between the two are still too indeterminate, for a model to reproduce the quantitative changes which will occur in nature. A well designed model will provide accurate information about the tides and the general flow pattern in an estuary or tidal river, but in the present state of knowledge of loose-boundary hydraulics, the experience of the engineer and the skill of the experimenter are essential for the successful planning of the experiments and for the interpretation of the results in relation to the behaviour of the prototype. Basic research into the laws governing the behaviour and transport of solid grains

does, the regime of the entire estuary. The nature of the experimental work will be similar to that described for Tilbury Basin. The effects of different upland discharges, corresponding to actual summer and winter conditions, will require close study, as it is known that the silting in these reaches is closely related to the fresh water flow, small though it is in comparison with the tidal discharge. Other factors which may affect silting in the area are the discharge by the L.C.C. of up to 400 million gallons per day of partially treated sewage into Barking Reach, and the progressive rise in the temperature of the river water due to the discharge of heated water from power stations.

Silting in the Royal Docks would automatically decrease if it were found possible to improve the condition of the Mud Reaches, as the water used for maintaining the impounded water level in the docks is pumped directly from Gallions Reach. Under the existing conditions, however, it may be possible to reduce silting in the docks by modifying the pump intakes to ensure that the least-silt-bearing water is used for impounding and by localising the area of deposition in the docks to facilitate such dredging as remained necessary. Such projects would be designed after an intensive study of the area in the model, and after testing

PART OF PILOT MODEL

in water is now being carried out by the Hydraulic Research Station, the results of which will, it is anticipated, go far to establish such *ad hoc* work on a firm mathematical basis.

In connection with the silting in Tilbury Basin, it is intended first to make a detailed survey of the surface and sub-surface currents in the model in the vicinity of the Basin, at all stages of the tide and with various upland, fresh-water flows. These measurements will be compared with similar observations in the prototype; any adjustments that may be needed to ensure similitude in the model will then be made, and further corroborative model observations taken. From these observations it will be possible to decide whether the problem can be solved directly by observations in the Thames model, or whether a larger, part model of the Tilbury area, with little or no vertical exaggeration, will be needed to obtain the requisite information. Material of low specific gravity, suitable for injection, will be used in the model to demonstrate the behaviour of silt and suspended material in the prototype, after which various proposals for improving conditions in the basin will be investigated. Whether these remedies will be of the nature of training works in the river or of structural alterations to the basin it is not at present possible to say.

The problem of silting in the Mud Reaches presents greater difficulties, affecting as it in it any proposed structures. A part model to a large scale might be needed for some of these tests.

"Safety" Colour Code

DURING recent years industry has given increasing attention to colour coding of danger points in factories to indicate high-voltage lines, toxic gases, and obstructions such as low doorways and steps and other varying degrees of hazard, and a committee of the British Standards Institution, representative of a wide variety of experience, has been considering the possibility of preparing a "safety" colour code to secure unification of the present different practices.

The Royal Society for the Prevention of Accidents made an extensive inquiry on behalf of the committee, and it has now been decided to abandon the attempt to prepare a code. The reasons for this decision, as summarised in a communication from the British Standards Institution, are set out herewith. Examination of the problem showed that a distinction must be made between a safety colour code and an identification colour code, the purpose of the former being, broadly, to classify kinds of hazard and to give warning of them by colour, whilst the object of the identification code, as in the British Standards 1710 for pipe-lines and 349 for gas cylinders, is primarily to identify by colour the contents, and any application to safety is incidental.

It was the former kind of code that the committee had to consider, and it was found that many colours had traditional connotations which, whilst not always consistent, were so well known that they could not be reconciled. The second difficulty was that the only truly satisfactory method of ensuring safety was to eliminate the hazard, and the committee felt that a code might encourage identification of hazards by colour instead of their removal. Thirdly, the increase in the scientific use of colours for decoration to secure better light and to improve working conditions, detracted from the effectiveness of a safety colour code, and these schemes of colour treatment were considered to be more effective in the reduction of accidents. Fourthly, positive evidence showed that the significance of colour codes put into effect had been quickly forgotten. Whilst this was relatively unimportant in the case of an identification colour code where time is not vital, it was felt to militate seriously against the use of a safety code where recognition and significance of colour must be immediate and instinctive.

Vehicular Rear Lighting

FOLLOWING complaints that the rear lighting of commercial vehicles was inadequate, British Road Services is planning to equip all its vehicles with new twin rear lamps. In this connection C.A.V., Ltd., Acton, London, has supplied the following details of a combined stop and rear light, as shown in our illustration.

Each lamp has a 3¾in aperture and comprises a metal base plate, to which is screwed a lampholder carrying two tail lamp bulbs and one higher wattage stop lamp bulb. The two tail lamp bulbs are wired in parallel; thus, should one fail, the other will still afford sufficient illumination for safe running. Two fixing bolts

COMBINED STOP AND TAIL LAMP

are provided for easy attachment to any suitable rear panel, plate or board, cable entry being by means of a three-way waterproof rubber grommet.

The lampholder assembly is fully enclosed by a thick glass body, which is itself protected by means of the rubber surround, the latter being suitably cut away to provide illumination for the number plate. The end face of the body incorporates a moulded "bull's-eye" which is located immediately over the stop lamp bulb and serves to intensify the illumination given by it.

The ruby glass is separate and is accommodated in a channel in the rubber housing, so that the three parts—rubber surround, body and ruby lens—normally form one assembly, held in position by a flat-headed screw. When in position, the screw exerts pressure on the joint faces between the ruby glass, the body and the lampholder assembly, the rubber housing being arranged to form the seals.

Marine Gas Turbines and the Aeronautical Engineer

INSTITUTION OF MECHANICAL ENGINEERS

No. I

AT a general meeting of the Institution of Mechanical Engineers, on Friday, January 25th last, Mr. A. Holmes Fletcher presented a paper entitled "The Marine Gas Turbine from the Viewpoint of an Aeronautical Engineer." An abstract of the paper is reproduced elsewhere in this issue and an abstract of the discussion is given herewith.

Discussion

Mr. R. J. Welsh, in opening the discussion, said that he found himself in very full agreement with the author in practically all that he had to say about gas turbines. His own gas turbine team had already built a gas turbine intended, among other things, for marine propulsion which embodied to a greater or less extent all ten of the aeronautical features which the author recommended.

His agreement with the author unfortunately broke down as soon as the author left the gas turbine proper and started to deal with items external to it. He disagreed with the author, for example, in the assumption that whatever method of burning vanadium-bearing fuels ultimately proved successful, it would not have any influence on the general temperatures or design features of the engine. He submitted that it would be wise at the present juncture to design marine gas turbines in such a way that, as far as one could see, they would be readily adaptable to take whatever sort of devices, appliances or contraptions might later be found necessary to deal with the corrosive ash problem. In general, it might be better to have the combustion chamber separate from the engine and mounted alongside or on top of it, rather than wrapped symmetrically round it.

He disagreed with the author's solution of the reversing problem. He did not think the time was yet ripe for the use of the variable-pitch propeller. The marine variable-pitch propeller was a much more difficult proposition than its aero counterpart. In the case of an aircraft propeller the loading was almost entirely centrifugal with hardly any bending; in a marine propeller the centrifugal loading was almost negligible, whereas the bending loads were severe. Bending loads were much more difficult to deal with in any boss or hub of reasonable dimensions. In general, he felt that although the variable-pitch propeller might be the long-term solution to the problem, until both it and the marine gas turbine were more fully developed and their reliability proved and accepted, it would be unwise to combine two such experimental features in any one ship.

He thought that the chief reasons why shipowners were not flocking to buy marine gas turbines were: first, that it was not yet possible to burn heavy oil with consistent success; secondly, that reversing means had not yet been fully developed commercially in the appropriate powers and speeds; and thirdly, that the reliability of the gas turbine was not yet sufficiently well established for it to be attractive for a single-engine, single-screw ship.

Dr. D. M. Smith commented on the author's statement that the multiplication of flame tube combustion chambers gave advantages of symmetry and increased combustion volume. So far as aero-engine practice was concerned, experience had shown that these and other advantages were even better attained by the use of a single annular combustion chamber. The only disadvantage of that from the author's point of view was that it did not fit in nicely with a centrifugal compressor!

The axial-flow compressor, whose peak efficiencies were plotted, was designed for a pressure ratio of 6 : 1, while the "Nene" compressor was presumably designed for a pressure ratio of 4 : 1. To enable a fair comparison to be made between axial and centrifugal peak efficiencies, curves ought to be plotted in the same figure for an axial-flow compressor designed for pressure ratio 4 : 1, and for a centrifugal compressor (presumably two-stage) designed for a pressure ratio of 6 : 1. The figures as they stood rendered comparison between centrifugal compressors and axial-flow compressors completely misleading.

In the case of concentric rotor designs, as exemplified by the "Clyde" arrangement, the bearing problem might be a difficult one. The peripheral velocities required for ball and roller bearings in the main running line of aero gas turbines were far above the makers' catalogue limits, and were so high that renewal of bearings every 300 to 1000 hours was imperative to give reasonable assurance against failure in service. He did not think that marine superintendent engineers would welcome having to do that.

He suggested that the author had not drawn a sufficiently strong distinction between the requirements for naval vessels and the requirements for merchant marine vessels. In his view, the differences were so far-reaching that totally different types of engines, developed by totally different techniques, were appropriate to the respective applications.

For the merchant marine long periods had to be spent in cruising at a high proportion of the maximum load; low fuel cost was imperative; very long periods of service between overhauls were required, and the benefits arising from reduction in size and weight of engine were not nearly so great as in naval vessels, let alone aircraft. In consequence, the most advantageous type of plant for merchant ships was heavier and more robust than that in naval vessels. Highly rated short and medium-life gas turbines based on aircraft practice were altogether out of place in the merchant marine.

In conclusion, he mentioned his most emphatic disagreement with the paragraph in which Fig. 3 was set. The author stated that a reduction of 50 deg. Cent. gave the life of turbine blading (as judged by creep tests) ten times longer, and therefore that a turbine operating at temperature 100 deg. Cent. higher would give a life ten times longer if the blading was cooled 150 deg. Cent. There were quite a number of fallacies in that statement.

Captain (E.) H. F. Atkins agreed with Dr. Smith in thinking that the author had not made an entirely convincing case for the use of this type of gas turbine in merchant ships, where there was not at present the same incentive to save weight in the engines nor space in the engine-rooms and where the reduction of the warming-up period, a big advantage in a warship, did not matter so very much.

Owners would certainly not like the idea of changing the turbine unit every two years. He suggested that this would cost a lot more than a boiler cleaning would cost. Nor would the owners lightly fit the variable-pitch propeller, involving docking the ship if anything went wrong. The aircraft propeller had a considerably easier life than a ship propeller, and it could, of course, be examined far more often.

He felt that the aeronautical engineer might try to pander a little to the marine engineer's weakness for being able to inspect bearings without stripping the whole engine. In the air, he supposed, one could not do anything about a hot bearing—and for a short time ignorance would be bliss! But at sea it might be possible to nip incipient bearing trouble in the bud. He hoped that the marine engineer might at least be spared from concentric shafts.

There were two questions from the national standpoint. First, could the country afford quantities of strategic materials to be employed where another type of engine not needing them could equally well be used? Secondly, was it desirable that much marine work should go to aircraft gas turbine builders, even if they had the capacity for it in peace? (In war they would almost certainly have to devote all their production to aircraft engines.) If not, could marine engineering firms adopt aero-engine practice without vast outlay in machine tools and much training?

The suggestion of connecting the propeller pitch control, the clutch control and the engine throttle to a single lever to be waggled by the captain from the bridge through the engine-room telegraph was, to his mind, a nightmare of centralisation.

Mr. B. E. G. Forsling said that the paper raised the old gas turbine controversy of the higher efficiency prime mover operating on the less efficient cycle (i.e., lower initial gas temperature) versus the lower efficiency prime mover operating on the more efficient cycle (i.e., higher initial gas temperature). Unfortunately, it was not at present possible to build a turbine which gave a very high thermodynamic efficiency and was also capable of operating with very high initial gas temperature. One had therefore to choose whether the emphasis should be on obtaining high component efficiencies or on a high initial gas temperature.

According to which choice was made, two virtually opposite designs might therefore be obtained, depending on whether the emphasis was on component efficiencies or on high initial gas temperature.

As an example, a small highly rated combustion chamber of aircraft type required a pressure drop of about 5 per cent. By increasing the size of the combustion chamber the pressure drop might be reduced to, say, 2·5 per cent, which corresponded to a gain of over 5 per cent in net output—200 h.p. on a 4000 h.p. set. Here the larger, heavier and lower rated combustion chamber was obviously preferable.

In view of the admitted importance of keeping the pressure drop low, he was surprised that the author had adopted a heat exchanger design with 0·25in diameter tubes and put the thermal ratio as high as 80 per cent. He would have thought that a larger tube diameter and a somewhat lower thermal ratio would have been preferable.

It should be noted that the heavier gas turbine, with emphasis on component efficiencies, had almost exactly the same specific output for the comparative cycle of the light

gas turbine, with emphasis on high initial gas temperature, at the present maximum permissible temperature of about 1100 deg. K. (1320 deg. Fah.). This meant that the heat transfer surfaces of the intercooler and the heat exchanger, with the same thermal ratios and pressure drops, would be about the same for both the heavier and the light gas turbine.

He thought the author was unduly concerned about the loss in efficiency due to deposit on the blading (axial) when operating in a town atmosphere. The gas turbine set for the "Auris" had run in the factory for a period of nearly 600 hours without cleaning, and there had been no falling-off in compressor efficiency, although no air intake filter had been provided. It had also been found that the compressor appeared to be not very sensitive to sea water spray.

At present the heavier gas turbine with high component efficiencies and operating at a moderate initial gas temperature appeared to have the best prospects.

Mr. G. B. R. Feilden said that many of the land and marine gas turbines which had so far been described in technical literature had closely resembled current steam turbine practice and had involved large masses of heat-resisting material, parts of which were called upon to expand and contract over the full temperature range through which the plant operated. At best this type of construction imposed severe restrictions upon the speed at which the plant would accelerate on starting up, and long periods of blowing over were considered necessary after shutting down.

In the Ruston and Hornsby gas turbine, with which he had been concerned, ample vindication had been obtained of the validity of the author's suggestion that not more than two-stage turbines should be used. In a total running time to date of just under 2000 hours, some 510 starts had been made on that plant, and the average time from first pressing the starter button to reaching operating load had been about six minutes. On no occasion throughout running had the plant been burning over after shut down.

He suggested that the time had come to have a term (the term "kinematic" was used at present) which might be used to indicate the type of construction which was capable of withstanding large and rapid temperature changes without causing itself any agony. Someone might have a better word to offer than "kinematic," but he hoped that there would before very long be agreement on such a word, because the term was a very necessary one in this branch of technology.

The main snag which the author was imputing to double-skin constructions was the possibility of fires. He admitted frankly that there had been one fire in the (Ruston) double-skin construction in the very early days during the first thirty hours of running. Nothing had been known about it until the plant had been stripped some time later. It had been suspected that something was wrong, since blue smoke had appeared in the exhaust—and the combustion was not as bad as that! The cause had been that one oil seal had been misplaced, and the oil from the main pressure feed pipe had poured into the lagging. The lesson had been learned, and the oil feed had been put in a different place in subsequent plants.

The advantages of double-skin construction had been eloquently stated by the author. His own firm's experience had been that the double-skin part of the plant had caused the least trouble of all. As was stated in the paper, joints working at these high temperatures could be troublesome, but by the use of double-skin construction one got an outer pressure bearing member at a moderate temperature when normal jointing methods were applied.

Mr. A. C. Walker agreed with the author's remarks on engine mounting. An engine mounting should be designed (*a*) to transmit torque, and (*b*) to support the weight of the power plant—and nothing further. The idea of putting a foundation bolt in every place where the power plant approached a bedplate was out of date. He agreed fully with the author's comments on the importance in designing the turbine support of avoiding feeding bolt vibrations to the turbine. In the past it had been, in the main, the power plant which had fed vibrations to the ship—this having been a source of some trouble to the naval architect—but in years to come the position might be the other way round.

On the question of propeller efficiency, he said that his firm had tested torpedo type fixed-pitch propellers in a modern cavitation tunnel. In 1947 Mr. Bell had read a paper in which the efficiency of a good fixed-pitch propeller tested in that tunnel had been given as 72 per cent. In the same tunnel a variable-pitch propeller had been tested and this had given a percentage of 70; so that there really was not a 15 per cent difference between the two.

Dr. A. T. Bowden said that, influenced by aircraft practice, the author had shown a layout which was extremely economical both as to space and weight, but the very compactness of the design militated against the successful usage of the cheaper types of residual oil fuels. The design itself was not free from criticism. On the one hand, the author generously helped himself to an operating temperature of 1200 deg. K. and to a large extent threw away the gain thus obtained by accepting a 20 per cent pressure loss. The author referred to the modest pressure loss in the combustion chambers, but this, in the light of present operating experience in industrial gas turbines, was needlessly extravagant. Had the author been less concerned with the streamlined design, so essential in aircraft practice, and taken advantage of a little more space in width and considerably more space in depth, he could have increased the size of the combustion chamber and ducting and reduced pressure losses very considerably, at the same time very greatly increasing the accessibility of the separate components and thereby increasing reliability.

The heat exchanger, for example, might well have been placed above or below the centre line of the power and compressor units. The gases could have passed through tubes of much larger diameter than those shown, thus making for easy cleaning. Experience to date with small tubes of the type envisaged by the author, where air passed through the tubes, indicated that for cleaning purposes, more for fire protection than heat transfer purposes, access must be available to the whole of the tube bundle. The inconvenience of stripping the outer casing to gain access to the tubes could only be imagined.

As far as he was aware, this was the first time that an 80 per cent thermal ratio heat exchange had been proposed for an open-cycle unit. Even with the small tube design envisaged, the cost was likely to be prohibitive if the pressure drop was to be maintained at a reasonably economical level. The pressure drops in the small experimental heater were not reported, but if they were not to be exceeded a similar design of exchanger with four gas passes would require at least three times the heat transfer area to give a thermal ratio of 80 per cent. With similar velocities the increase would be about two and a half times.

He wanted also to take up the author on the use of multiple combustion chambers. The difficulty of maintaining equal flow in a large number of chambers, particularly when using heavy oil fuel, had already been amply demonstrated in units of similar type now operating in the United States. Where the outlets from multiple chambers were led directly on to the first nozzle ring the total output of the machine might well have to be reduced in order to accommodate itself to greater than average temperature of a combustion chamber or group of combustion chambers. For that reason alone there was a great incentive to confine the combustion chambers for a marine unit to one or possibly two.

No one would quarrel with an urge to condense the space occupied by a gas turbine or to lighten its components; indeed, all industrial tendencies were in that direction; but apart from such considerations as he had already outlined, it must be remembered that the higher component loadings associated with condensed machine volume demanded levels of inspection and material control that were typical of aircraft rather than industrial practice, and unless units of the type under discussion were made in very large numbers it was doubtful whether such control systems could, in fact, be tolerated.

As speed increased and loading and stress increased the effect of a defect was increased. The loss of a single blade or, for that matter, a group of blades in a multi-stage turbine might only result in rather rough running, but a similar loss in a high-speed single or two-stage overhung turbine might be disastrous.

By those remarks he did not imply that a light, highly loaded machine was necessarily unreliable or undesirable, but the latitude for reliability was small and meticulous inspection and control, which could only be obtained at very considerable expense, were essential, and it was doubtful whether such a system could economically obtain outside a firm already engaged in large-scale production of lightweight units. High rotational speeds demanded by the compact design suggested by the author could, of course, be applied to both present-day steam and diesel propulsion machinery, and the idea of numbers of light high-speed short-life reciprocating engines, each contributing its quota to the final output shaft, had been advocated from time to time, but had not found much favour when their use had been seriously considered. There was bound to be some preference for the use of more lightly loaded, heavier machinery of a non-expendable type.

Nevertheless, the gas turbine was, in comparison with its competitors, a low-pressure engine. It was also a variable-temperature engine. Those factors demanded a light symmetrical construction and in its accepted design would, he felt sure, conform more closely to aircraft than present marine and industrial conceptions. Viewed in this light, the author's contribution had been particularly invaluable. The author might be a little before his time, perhaps, but certainly he was not a lone voice crying in the wilderness.

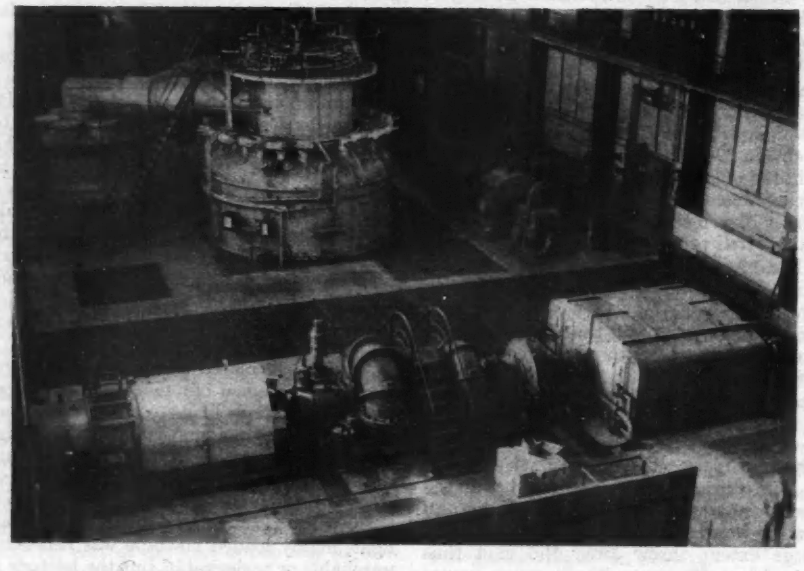
(*To be continued*)

PATENT OFFICE LIBRARY.—It has been decided to continue the extended hours of opening of the Patent Office Library at 25, Southampton Buildings, Chancery Lane, London, W.C.2. The hours are 10 a.m. to 9 p.m., Monday to Friday, and 10 a.m. to 5 p.m. on Saturday. The extended hours of opening were first introduced last May.

12·5MW Gas Turbine Set at St. Denis Power Station, Paris

IN the early part of 1951, the erection of the first industrial Escher Wyss 12,500kW, Ackeret-Keller closed-cycle gas turbine set was completed at the St. Denis (Paris) power station of the Electricité de France.

The set has been designed and built to deal with the basic load, and it is equipped with the necessary auxiliary apparatus to take load variations. It was decided to carry out a complete programme of technical tests on



12·5MW ESCHER WYSS CLOSED-CYCLE POWER PLANT

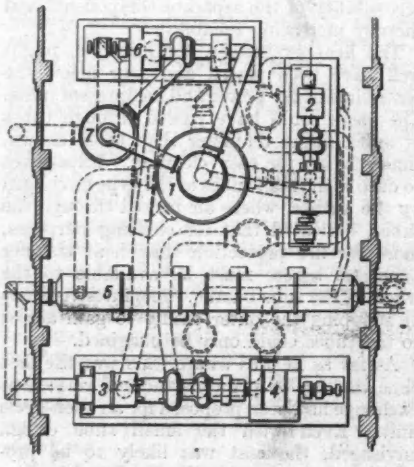
load, which was done by the makers, the Escher Wyss Company, of Zürich Switzerland, and the engineers of the power authority. To make these tests possible a complete set of measuring instruments was installed.

In the accompanying engraving we show an overhead view of the power plant, which was adapted to fill the space left when another set was taken out. The whole arrangement does not quite accord with the ideal lay-out, and the general grouping of the turbine and generator with the air heater is clearly shown in the drawing and legend. The photograph shows the upper part of the oil-fired air heater, which operates at a combustion chamber pressure of 2 atm. The four oil burners are mounted in the top of the heater and are given easy access by a step ladder. Behind the ladder is the preheater for the combustion air. The charging compressor of the combustion air is arranged behind the air heater and preheater, and is shown in the drawing. To the right of the central air heater is the high-pressure turbine, which drives the high-pressure air compressor. This group has a starting motor. In the foreground is the low-pressure turbine with the low-pressure compressor, and on the extreme right the 13,000kVA generator. Between the air heater and the low-pressure group there is the heat exchanger, which, as shown in the drawing, is accommodated in the basement together with the intercoolers for the compressors and the pipe connections between the various units. The switchboard and the control room can be seen in the gallery above the plant.

During 1951 a better lay-out was evolved in which the high and low-pressure turbine and compressor groups are mounted in line with the heat exchanger arranged below, and the intercoolers nearby. This gives the best arrangement for the conduits and piping between the air heater and the turbines, and reduces, therefore, the first cost of the installation. Such an arrangement was not, however, possible at St. Denis, and at Carolina Port power station, Dundee, where a similar 12,500kW set built under Escher Wyss licence by John Brown and Co., Ltd., of Clydebank, is being installed.

The St. Denis plant, described and illustrated herewith, has been designed for an efficiency of over 30 per cent with a maximum cycle pressure of 50 atmospheres and an inlet temperature of 675 deg. Cent. After preliminary running tests the set was connected to the Electricité de France supply system in November, 1951, and since that time load tests with the entire group in operation have been made. Apart from minor troubles mainly connected with auxiliary plant, the different runs, which were concluded on Tuesday, January 15, 1952, gave very satisfactory results. The mechanical behaviour of the machines as well as the performance of the auxiliary plant and the air heater, fulfilled all expectations. The starting up of the plant and its regulation during the idling period and under load with normal running, was carried out without incident. Up to January 15th, two continuous runs, each over 100 hours, with inlet temperatures well above 600 deg. Cent, were made. Apart from these continuous runs, some shorter runs were also made in order to check the operation of the various measuring instruments and safety devices.

It is recognised that the operation of this first large closed-cycle gas turbine power plant presents a number of new engineering problems. The series of tests according to the agreement between the engineers of the power authority and Escher Wyss, are now well under way. The final results can only be given after prolonged service running at the higher loads. The first phase of these trial runs, which was intended to make the operating personnel familiar with the behaviour of the whole installation running under normal service condition, was, we learn, carried out at approximately one-third load.



1. Air heater
2. H.P. group with starting motor
3. L.P. group
4. Generator
5. Heat exchanger
6. Charging compressor for combustion air
7. Preheater for combustion air

PLAN OF INSTALLATION

A Cathode Ray Tube for High Speed Oscillography

WE learn that a new cathode-ray tube, known as the "908 C.A.R.A.," is being produced by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, for use in high-speed oscillography. The tube, which utilises electrostatic focussing and deflection, has a 9cm diameter flat-faced screen coated with a highly actinic powder giving a blue fluorescence. One stage of post-deflection acceleration is employed, which enables the beam to be accelerated after the main deflection has taken place. Connections to the front plates are brought out of the envelope via side arms, whilst the connections to the back plates and the third anode are taken through the base.

The operating conditions of the new tube, "908 C.A.R.A.," are as follows :—

Heater voltage	4·0V
Heater current	1·1A
First anode voltage	2·0kV
Second anode voltage (focus), approximately	220V
Third anode voltage	4kV
Post-deflection accelerator voltage...	8kV
Cut-off voltage, approximately	−70V
Back plate sensitivity, per volt	0·11mm
Front plate sensitivity, per volt	0·08mm

This new tube is the same as the Services type "VCRX.294," and it has the same size and kind of screen as the G.E.C. "908 B.C.C.," but it differs in the following details :—First, the "908 B.C.C." has five side arms, while the "908 C.A.R.A." only two; the consequent saving of space is advantageous where a number of tubes have to be used in a multi-channel recorder. Secondly, it has a stage of post-deflection acceleration; the "908 B.C.C." has not. Thirdly, it is suitable for work which demands a better tube than the "E.4412.B.9," but does not justify the use of the more elaborate "908 B.C.C." tube.

GEOPHYSICISTS' ASSOCIATION.—During the third World Petroleum Congress, held in June of last year, the European Association of Exploration Geophysicists was formed. The inaugural meeting was held at the Association's headquarters at The Hague when Mr. A. van Weelden, director of research, De Bataafsche Petroleum Maatschappij, was elected president. Membership numbers 320 geophysicists from thirteen countries. Following the meeting the following six papers were read :—"Geometric Problems Originated by Reflection Seismic in Mines," by Dipl. Ing. H. Linsser; "The Design of Electromagnetic Geophones," by Dr. D. T. Dennison; "Gravity Effect of Earth Tides," by Dr. B. Baars; "Earth Tilts and the Flow of Oil Wells," by Dr. R. Tomaschek; "Sur le Calcul de l'Influence Gravimetriques des Structures Defines par les Isobathes," by Mr. V. Baranov; "Some Examples of the Application of Isostasy," by Mr. J. W. de Bruyn.

The Marine Gas Turbine from the Viewpoint of an Aeronautical Engineer*

By A. HOLMES FLETCHER†

[DURING the first part of the paper the author reviewed the more obvious design characteristics of various typical aircraft turbines developing either jet or propeller thrust. References made included those relating to the form of compression, systems of combustion, symmetry of engine design, coupling of compressor and turbines, and fastenings and supports, amongst others.]

Before an attempt to produce a scheme for a marine turbine, the points to which attention should be paid in order to take advantage of aero developments and other features may be summarised as below:

(1) To avoid matching difficulties and to give maximum robustness of the design, centrifugal compressors should be used if the required performance can be achieved with compression ratios around 3/1.

(2) Single or two-stage turbines should be used, to give good matching and to reduce blade temperatures and the amount of metal in the turbine assembly.

(3) If difficulty arises in the handling of the high-velocity turbine exhausts, a solution on the lines of the "Clyde" engine with concentric high-pressure and power shaft systems may be employed.

(4) The air-flow paths must be kept as simple and as direct as possible.

(5) The design should be symmetrical, to avoid temperature or pressure distortions involving the use of multiple combustion chambers. It is to be accepted for the time being that no change in this basic rule will be enforced by provisions necessary for the burning of residual fuels.

(6) The power turbine is to be mechanically independent.

(7) Care is to be taken in the detail design to avoid redundancy of supports, to permit freedom for thermal expansions, and to use the minimum of metal. Longitudinal joints in the turbine casings are to be avoided, and flanged joints are to be reduced to the fewest possible.

NON-AERO COMPONENTS

The Heat Exchanger.—The compound marine turbine cycle will incorporate two component units which are not usually found on aero-engines. These are the heat exchanger and the intercooler.

The illustration reproduced below, Fig. 1, shows a small heat exchanger which was made for experimental purposes, and in the design of which great care was taken faithfully to follow the precepts deduced from aircraft turbine practice. By its nature the heat exchanger is a difficult design problem, since it deals with gases of very different temperatures in adjacent casings, and the avoidance of temperature stressing under these conditions calls for great ingenuity on the part of the designer.

It was decided to use an annular tube matrix with the hot gas making two radial passes across the tubes and the air passing through the tubes in the reverse direction. It will be appreciated that this lay-out gives uniform circumferential temperature distribution, and that since the outer tube row exists with half its length in the hottest gas and half in the coldest, while the innermost row is in gas at the average temperature along its whole length, differential expansion effects between the tubes are very small and there is little stressing of the tube attachment points.

The exchanger was to give 63 per cent thermal ratio with an air mass flow of 14 lb per second and a gas entry temperature of 550 deg. Cent. (1022 deg. Fah.). To achieve this performance 4280 tubes of 0·250in diameter and 4ft length "Staybrite" steel were needed, these being roller-expanded into the two end plates and passing through the annular splitter plates seen assembled in a jig for tubing in Fig. 1. The central plate of this assembly was bolted between the two halves of the outer casing to form the baffle which made the gas perform the two passes required. The air was brought in at the gas inlet end through a duct lying along the axis of the tube matrix, and this duct delivered into a chamber formed by the closing of the forward end of the tube stack by a domed steel cover. A cast steel collector bolted to the other tube plate brought the heated air to the outlet connections.

The three-point mounting trunnions supported the matrix assembly; the outer casing, of thin stainless steel, enclosed the matrix and rested on the trunnions for support, but with suitable glands permitting relative expansion.

All the trunnions and ducts which passed through the outer casing were arranged so that their axes met on a common focal point, from which centre expansion was to occur.

For its preliminary tests, this heat exchanger was supplied with air from a "Derwent" compressor, the air passing through the tubes and then being brought out to a heating chamber for recirculation through the gas circuit of the exchanger. It performed satisfactorily, and in this and subsequent testing it completed over 700 hours of running without trouble of any kind. The tests included deliberate attempts to foul the heat exchanger by running the heating chamber excessively rich, but no change in performance could be detected. Soot appeared to collect only on the colder portions of the tube stack in such a thin layer that it had little influence on the heat transfer rate or on pressure drop figures.

By an increase in dimensions and the use of four gas passes, an exchanger of this type can be made to give a thermal ratio of 80 per cent.

The Intercooler.—Similar temperature difference problems exist in the intercooler, but the lower temperature level of this unit eases the designer's task, as use may be made of rubber for sealing and mounting purposes.

Secondary surface matrices show some advantage, permitting the use of larger tubes and thus reducing fouling tendencies and easing cleaning; but as a finned-tube matrix will probably need a rectangular casing, there will be the problem of stiffening to carry the pressure stresses. A lighter assembly will probably result from the use of an annular design with plain tubes, on the general lines of the heat exchanger described above.

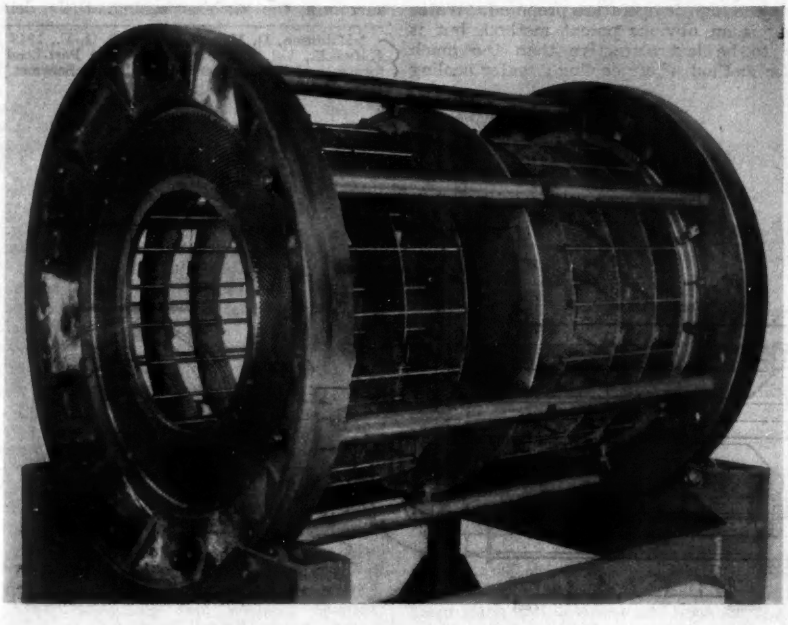


FIG. 1—*Heat Exchanger Matrix in Jig for Tubing*

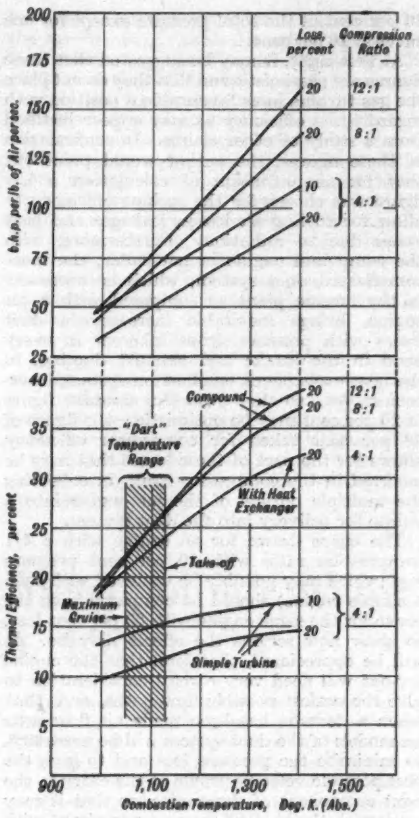


FIG. 2—*Performance Curves for Various Gas Turbines*

DERIVATION OF THE MARINE TURBINE LAY-OUT

Mention has previously been made of the desirability of choosing a compound cycle for a marine plant to give economy under part-load conditions. While this is undoubtedly important for naval vessels, it might not be considered worth while on merchant ships which spend most of their lives at or near full power. The higher compression ratios which compounding permits, however, also show advantages at full power as may be seen from the curves in Fig. 2. These show full load efficiency and b.h.p. per lb. of air for a few possible cycles plotted against combustion temperature.

For the purposes of calculation of these curves, the assumed data comprised 78 per cent adiabatic efficiency for the compressors as should be achieved with the recommended centrifugal type, 82 per cent for the expansion efficiency, and 80 per cent thermal ratio for both the heat exchanger and the intercooler. Pressure loss in the engine has been taken at

* Abstract from a paper presented to the Institution of Mechanical Engineers. January 25th.

† Chief designer, Marine Division, Rolls-Royce, Ltd.

20 per cent of the total pressure except for one curve at 10 per cent.

At first sight, it may be suggested that these figures are pessimistic and that they do not place the gas turbine in as favourable a position with regard to its efficiency as may appear justified from a study of other claims. In confirmation of these figures, the author would point out that for simplification of calculation a low figure was chosen for the turbine efficiency to allow for cooling air losses, leakages and heat losses due to radiation. Furthermore, with the compound engine in particular, the more complicated duct system, which is necessary in the marine plant as compared with a jet engine, brings inevitable increases in duct losses with pressure drops inherent in every bend in the intake and exhaust ducting, in the heat exchangers, combustion system, intercoolers, &c., so that even the assumed figure of 20 per cent may be optimistic; the figure of 78 per cent taken for compressor efficiency allows for the part of these losses that may be incurred in the compressor itself, in collecting the multiple outlets of the jet engine into a volute for delivery into the duct system.

The curve drawn for an engine with a 4/1 compression ratio with 10 per cent pressure loss (which may possibly be achieved with such a simple engine) should be compared with the curve for the same engine with 20 per cent loss, to show how serious the effects may be. It will be appreciated, therefore, that the engine lay-out will need very careful consideration to give the easiest possible flow paths, and that when a decision has been made air flow tests on models of the duct system will be necessary, to minimise the pressure loss and to give the best possible velocity profile at the entry to the next component of the engine, so that it may work with the best efficiency concomitant with good entry conditions.

It will be seen from a consideration of the curves that if a target of 30 per cent overall efficiency is set for the marine plant, the simple 4/1 compression ratio engine with 80 per cent thermal ratio heat exchanger has to be run at a temperature of 1300 deg. K. (1880 deg. Fah.) to achieve it, but a compound engine of 8/1 overall ratio can give the required efficiency at a temperature 100 deg. lower. The latter engine has also a higher specific power, 90 b.h.p. per pound of air per second as against 78 b.h.p. per pound, which is an inverse index of the size of the deck openings required to pass the inlet and exhaust ducts.

A calculation has also been made of the performance of an engine with a 12/1 compression ratio on the assumption that 78 per cent compressor efficiency can still be maintained at the higher individual ratios needed to give this overall figure. This engine shows an improvement of only 1 per cent in efficiency over the 8/1 engine at 1200 deg. K. (1700 deg. Fah.) combustion temperature, although giving over 100 b.h.p. per pound specific power.

The part-load performance of the 8/1 engine has been investigated, showing that it should give a specific fuel consumption better than 0·5 lb per brake horsepower per hour, down as low as 23 per cent load, with a best economy of 0·45 lb per brake horsepower per hour at half-power.

Owing to the small advantage in efficiency shown by the 12/1 engine even if the individual compressor performance can be maintained, and the greater difficulty which will be involved with its bolted joints owing to the higher pressures, the conclusion is drawn that the 8/1 compound engine should be selected. What comments can be made, however, on the proposal to operate at 1200 deg. K. combustion temperature, when it will be seen from the temperature range of the "Dart" (Fig. 2) that this is appreciably above present-day aero practice?

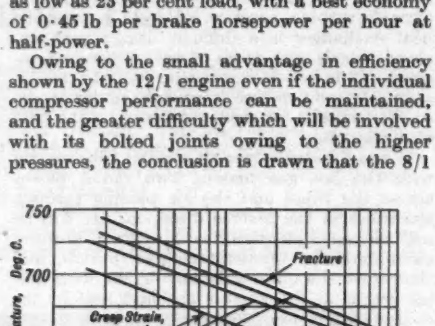


FIG. 4—*Effect of Temperature on the Life of Turbine Blades at Constant Stress*

Fig. 4 shows the effect of temperature on the life of turbine blade materials. It will be seen that a 50 deg. Cent. (122 deg. Fah. reduction in temperature gives a life over ten times longer, so that if the "Dart" will give a service life of 1000 hours at about 1100 deg. K. (1520 deg. Fah.), a turbine operating at 1200 deg. K. would require 150 deg. of blade cooling to give a life of 10,000 hours.

Now, this life represents two years' service in a merchant ship averaging 200 days at sea in twelve months. Since the turbine unit will be small and easily handled, is there any difficulty in accepting that it should be changed every two years for a reconditioned unit? It would even be possible to carry a spare turbine on board, changing over at any convenient time while the ship was in dock discharging cargo, and the time-expired turbine could then be sent back to the works for overhaul at leisure under the best possible conditions for the work.

With the acceptance of this proposal, it is now necessary to consider the method of achieving the required blade cooling for operation at the high temperature proposed. Water cooling is an obvious potent method, but it tends to be less attractive than the much simpler method of air cooling; water cooling involves complication and distilled make-up water must be provided—with the danger of complete and disastrous failure if a temporary stoppage occurs in the cooling circuit. The ease of incorporation of air cooling and its general suitability in aircraft work may lead to an expectation that aero designers will be actively exploring the possibilities in this direction in the near future.

For the blades themselves, it has been calculated that the required reduction in blade temperature of 150 deg. Cent. can be obtained by a fairly simple scheme of passages drilled up the blades, through which will be passed 3 per cent of the mass flow of the compressor as cooling air. The circulation of air up the blades unfortunately does lead to some loss. It does no work in the stage and reduces the work potential in later stages. A detailed calculation of its effects shows that the 3 per cent allowance in the example just mentioned reduces the overall efficiency by about 2¼ per cent, this being one of the factors covered by the deliberate choice of only 82 per cent for the expansion efficiency in the calculations. This method of allowing for losses is admittedly crude, and for expediency only, but the indications of these calculations are generally true.

Lay-Out of Turbine.—Having decided upon a compound engine with free power turbine, reference to Mallinson and Lewis's paper‡ (1948) will suggest that of the many ways of coupling up the component units, the most favourable will be that designated as the "2SC/IP/IE" type—that is, the engine will be a straight compound with the power turbine intermediate between the high-pressure and the low-pressure turbines. Reheat between the turbines is a complication which has not been considered in the present paper, as part of its object is to illustrate the fundamental simplicity of a gas turbine engine of quite competitive performance.

Bearing in mind the "Clyde" scheme of dealing with series turbines in order to reduce losses in the high-velocity exhaust gases, and remembering the suggested form of heat exchanger, it is not difficult to arrive at the turbine lay-out shown in Fig. 3. This engine should be capable of delivering 4000 s.h.p. under tropical intake conditions with a specific fuel consumption of 0·47 lb per horsepower per hour at full power; it should weigh not more than 6–10 tons.

It is seen that the high-pressure compressor is at the rear end of the assembly with the power shaft passing co-axially through the bores of the high-pressure turbine and compressor rotors and shafting. The low-pressure stages drive forward through the centre of the heat exchanger to the low-pressure compressor at the front. Seven combustion chambers surround the turbine casing, their delivery

‡ Mallinson, D. H. and Lewis, W. G. E., 1948 *Proc. I.Mech.E.*, Vol. 159, page 198, "The Part-Load Performance of Various Gas Turbine Engine Schemes."

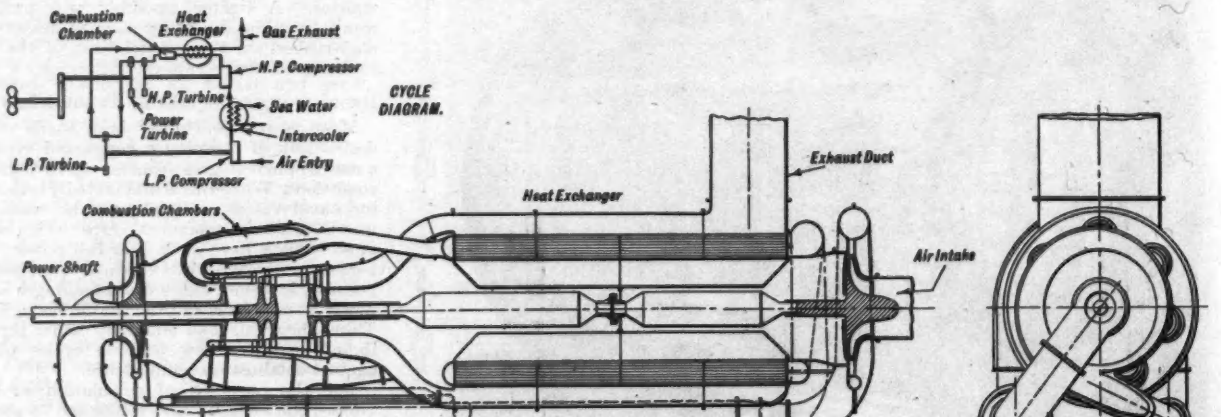


FIG. 3—*Lay-out of 4000 B.H.P. Gas Turbine*

ducts having to make a 180 deg. change of direction, but owing to the accelerating nature of the flow the losses here can be kept small. The expanding gas through the turbines is not changed in direction until its speed has been reduced by the diffuser and entry cone of the heat exchanger. The symmetry of the arrangement is noteworthy, being broken only by the accommodation of the intercooler which is placed as low in the ship as possible.

If the detail design of the engine follows aero practice as closely as possible, it should be possible to start it by a small electric motor of about 15 h.p. with an automatically controlled starting cycle completed within half a minute of pressing the starting button. With mechanically driven auxiliaries, the engine is then completely independent of external sources of power, and should require no more attention during running than the engine of a motor car.

In developing the engine, some trouble may be experienced with the burners owing to the necessity of providing even distribution and good atomisation throughout the flow range, from about 250 gallons per hour at full power down to about 3 or 4 gallons per hour when idling. Spray nozzles opened up in series as the flow increases might provide the solution, or perhaps some chambers might be extinguished at low powers, when an even number of chambers might be advisable.

Power Transmission.—The power turbine of the 4000 h.p. gas turbine runs at about 6000 r.p.m. at full power. It requires a reduction gear to couple it to the propeller shaft, and this gearing can be of the usual marine type except that some provision has to be made for reversing. The usual steam turbine practice of fitting a separate astern turbine wheel cannot be followed without considerable complication; there would have to be ducting with valves to control the gas flow to the turbines, and a clutching mechanism to detach the wheel from the shafting when not in use, otherwise the losses caused by the spinning astern turbine in ahead gear become prohibitive.

Electric transmission, which is a solution to the difficulty, is not favoured, as has been mentioned earlier; neither is the system proposed by PAMETRADA, in which direct and reversing fluid couplings, which are filled as required, involve losses in both the ahead and astern drives. A better method would be to accept the mechanical problems and use either an epicyclic or other gearing, in which the direction of rotation may be controlled by brakes or clutches; but when consideration is given to the energy which has to be dissipated in the brake or clutch linings during an emergency operation from full ahead to full astern, the designer might be excused if he began hoping for a scheme which did not involve this generation of heat within the mechanism.

Such a scheme is available in the variable-pitch propeller, well established in the aero world, and now made by several firms in large sizes for marine purposes. With this propeller, reversal of thrust does not necessarily mean a reversal of rotation, although if a reverse pitch is selected while the ship is moving at some speed ahead, the watermilling torque of the propeller might overcome the turbine torque at small throttle openings and drive the machinery backwards for a short time. During normal manœuvring, of course, this is not likely to occur, and delicate handling of the ship in harbour is possible with slight forward and astern pitch laid on as required with the turbine idling.

As regards the idling condition, as the throttle is closed and speeds fall, the matching of the turbine and compressor units deteriorates, component efficiencies become lower, and burner atomisation can be expected to fall off. Eventually, a point is reached at which conditions are generally so bad that temperatures have risen and the turbine becomes insensitive to throttle reopening, with a danger of overheating when an attempt is made to accelerate. The minimum running speed must be kept sufficiently above this point, at a figure at which running is steady and the turbine lively enough to accept increasing fuel without trouble. This means that an appreciable torque is always available from the power turbine, and with direct coupling to a fixed-pitch propeller there is a possibility that manœuvring at very low speeds may be very difficult. Here again the variable-pitch propellor shows an advantage.

Two criticisms may be levelled at the variable-pitch propeller. First, it has been claimed that its efficiency is anything up to 15 per cent lower than that of a fixed-pitch screw. The author is doubtful whether a direct comparison has been made between two screws designed for the same duty to decide this question, and also whether the types of variable-pitch propellers so far tested represent the optimum design.

Secondly, it would appear that when the turbine is started and before the ship gets under way, or wherever "stop" is signalled without "finished with engines," the variable-pitch propeller will be running round idly in zero pitch and a danger will arise of floating ropes becoming trapped. The answer to this is, of course, to have a clutch in the drive which disengages the turbine at these times; the turbine should not race away dangerously when disengaged as it is running only at idling power, but interconnection of the clutch control with the throttle is advisable for safety's sake. In fact, with the variable-pitch propeller, the pitch control, clutch control, and the engine throttle can be coupled to a single lever, and with the independence of the gas turbine from auxiliary machinery, complete bridge control of the machinery becomes a possibility. Engineers would, of course, be employed below to watch bearings, oil levels, &c., but the engine-room telegraph on the bridge can be directly connected with the engine control lever, and if the starter button were also on the bridge, the captain of the ship would have the engines as completely under his control as in his motor car.

Conclusion

This paper is presented as a design exercise, and the author would be gratified to see ships with turbines designed on the suggested lines eventually undergoing trials. He is quite prepared, however, to find his present ideas undergoing drastic modification owing to developments to-day proceeding as fast as they have ever done in the past.

Some Works of the Metropolitan Water Board in 1951

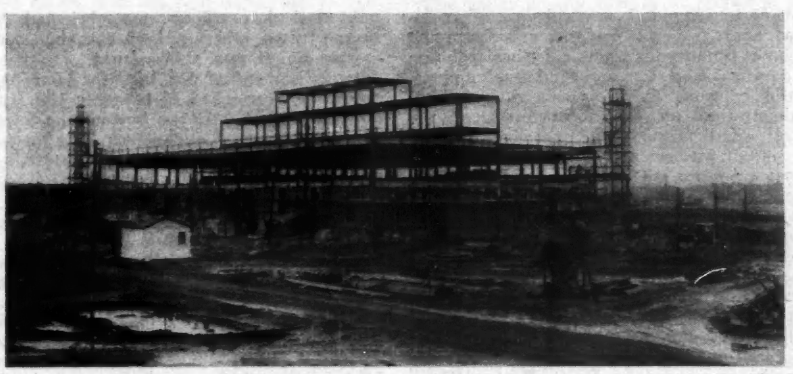
In past issues of The Engineer reference has been made to the two main problems confronting the Metropolitan Water Board—the provision of adequate storage reservoirs for the maintenance of the supply in times of drought and the construction of sufficient filtration plant to ensure the purity of supply. Owing to the restrictions on capital works, the Board was not able to resume work on the construction of the storage reservoir at Walton or commence work on the proposed new reservoirs at Wraysbury and Datchet during 1951. The new 90 m.g.d. plant in progress at Ashford Common will, when completed, help to relieve the filtration problem.

The scheme for a filtration works and pumping station at Ashford Common was described and illustrated in the issue of The Engineer of January 17, 1950. The whole of the civil engineering work with the exception of the raw water tunnel from Queen Mary reservoir is being carried out by John Mowlem and Co., Ltd., under two contracts, the first of which includes approximately one-half of the installation and the pumping station.

The mass concrete walls for the thirty-two slow sand filters were finished during the year and the laying of the porous concrete under-drains and the placing of the filter sand was completed for twenty-eight filters. Construction of the contact tank on the east side of the works was practically finished and the main walls and columns and floor for the west contact tank were substantially completed.

The main pump-house is shown under construction in the accompanying illustration. Following the completion of all structural work up to ground level and the erection of the whole of the structural steel framework, reinforced concrete roofs were constructed for the pump house and the generator house. Construction of the floors throughout the building was well advanced and the brickwork and masonry of the external walls above ground level was in progress. A start was made on the construction of the switchgear and transformer houses and the office block, which also form part of the main building.

Work was started by Kinnear Moodie and Co., Ltd., on the 96in internal diameter concrete-lined tunnel, which will bring raw water from the Queen Mary reservoir to the new works, a distance of about 630 yards. The tunnel will be driven through the London clay at a depth of about 90ft below ground level. A shaft is now being sunk at the west end, near the outlet from the Queen Mary reservoir, and as soon as it reaches its full depth, the work of driving the tunnel will be started. A contract was placed with Glenfield and Kennedy, Ltd., for the installation of twenty-four rotary straining units having a total capacity of 90 m.g.d. Each unit will consist of a drum 10ft in diameter and of 10ft effective length, with a stainless steel mesh fixed on the periphery and will be driven by an electric motor.



Construction of Pumping Station at Ashford Common

Chingford.—The new storage reservoir at Chingford was officially inaugurated by Mr.

William H. Girling, O.B.E., the Chairman of the Board, on Tuesday, September 4th last, and is now known as the William Girling reservoir. It has an available storage capacity of 3493 m.g. and, for the present, is being filled with raw water from the Lee by means of a gravity connection from King George V reservoir. Tenders for a new pumping station were obtained in 1951 and an order to start the work will be given to the contractors, Caffin and Co. Ltd., as soon as notice of approval of a starting date has been received from the Ministry of Housing and Local Government. The building was designed by L. G. Mouchel and Partners, Ltd., and its erection will be supervised by them. Electrically driven pumps, which will be automatically controlled by the river flow, are on order. The reservoir itself was described in our issue of October 12th last.

Hampton.—The remodelling scheme for increasing the capacity of the Hampton works from about 55 to 120 m.g.d., was substantially completed, apart from the new raw water pumping station at Sunnyside, a new chlorination house and a central sand store and sandwashing plant.

In July work was commenced by direct administration on the construction of the central sand store. The scheme includes four sets of washers and a reinforced concrete clean sand store with a capacity of approximately 18,000 cubic yards, together with the necessary sludge lagoon.

One further slow sand filter bed was reconstructed during the year, making a total of six beds completed of the twenty-nine low-level filters. Further work of reconstruction has been suspended whilst the men are engaged on the central sand store.

Hornsey and Stoke Newington.—Site work was recently commenced by R. G. Horton (Engineers), Ltd., on the construction of two contact and balancing tanks—one of 1½ million gallons capacity at Hornsey and one of 3½ million gallons capacity at Stoke Newington, for which the consulting engineers are Messrs. Binnie, Deacon and Gourley. These schemes also include low-lift pumping machinery, chemical treatment houses and ancillary works.

The tank at Hornsey is being constructed mostly above the general ground level. It will have a mass concrete floor, columns, side and division walls, with a reinforced concrete roof covered with asphalt. The tank will be surrounded with an earthen embankment sloped at 2 to 1.

At Stoke Newington the tank will be mainly below ground level. The site is congested and requires the preliminary diversion of various mains and services. In addition, the proximity of existing structures necessitates the extensive use of sheet piling. The tank will have a concrete and asphalt floor, reinforced concrete side and division walls and columns, with a reinforced concrete beam and slab roof protected by an asphalt covering.

Another interesting work at Stoke Newington, which was described in our issue of February 2, 1951, involves a new system of tunnelling for a length of 75in diameter water main, for which the consulting engineers are Sir William Halcrow and Partners. The 7ft 6in diameter tunnel has now been completed and sixty-six 15ft long steel pipes lined with cement mortar have been laid inside it. Useful experience of an experimental character was thus gained in laying and lining thin steel pipes in a tunnel of little greater diameter than the pipe.

Of the above pipes, sixty were of ¼in thick mild steel plate. They were fabricated at the makers' yard, where a 1in thick spun cement mortar lining was also applied. A specially designed apparatus was used for lowering the pipes, which weighed 4¾ tons per 15ft length, down the shaft. At the bottom the lowering gear was removed and a travelling gear consisting of a pipe supporting beam carried on two "A"-shaped bogies transported the pipes along the tunnel. When all pipes had been laid the joints were welded.

Six ¼in thick steel pipes were also laid and lined *in situ*. A ¼in thick cement mortar lining was placed by a "Centriline" machine (THE ENGINEER, October 12, 1951). In this machine a spinner rotating at constant speed throws mortar against the pipe wall and the surface is rendered smooth by slowly turning blades. The thickness of the coating is controlled by adjusting the speed of travel of the machine through the pipe.

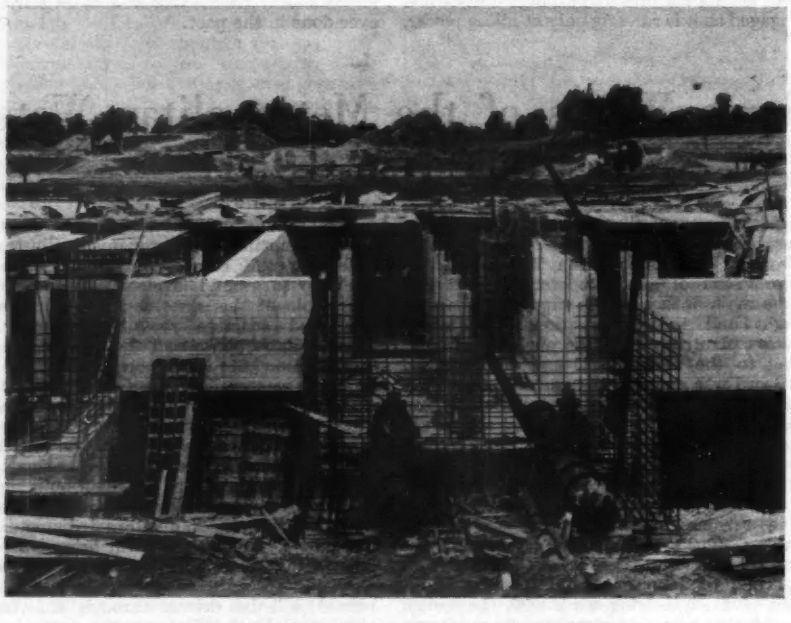
60in Trunk Main—Kempton Park to Cricklewood.—This main when completed will have a total length of 13¼ miles and will convey additional Thames water to North-West and North London. Section No. 1 of the main, a distance of 6034 yards, was completed and section No. 2, of 4580 lineal yards, was nearly finished. Good progress was made during the year by the J. L. Eve Construction Company, Ltd., on Section No. 3—Lyndhurst Avenue to Abbey Avenue, and 6050 lineal yards of main were laid out of a total length of 6950 lineal yards. The contract for Section No. 4—Abbey Avenue to Cricklewood (5726 yards) was awarded to J. B. Edwards and Co. (Whyteleafe), Ltd.; it includes 798 lineal yards of tunnel under railways and a canal. The tunnels are to be lined with cast iron segments of 9ft internal diameter, in which the pipes are laid, the space between the lining and the pipes being filled solid with concrete. Site work was commenced on June 6th last and 877 lineal yards were laid in open cut and 100 lineal yards in tunnel during the year.

A scheme for the laying of 30in, 24in, 20in, 15in and 12in mains from Eynsford and Horton Kirby to Bickley and the provision of a booster station for the improvement of the supply to the Kent area was also in progress in 1951. The work is being carried out by Whittaker Ellis, Ltd., and 1976 lineal yards of 20in and 420 lineal yards of 24in mains were laid out of total lengths of about 2400 and 6200 lineal yards, respectively.

Walton.—The construction of a concrete contact and balancing tank of approximately 2½ m.g. capacity was commenced by J. Jarvis and Sons, Ltd., in June, 1950, and is now nearing completion, and the two electrically-driven raw water pumping units are being installed. The illustration herewith shows the tank from the outlet end.

General.—During 1951 low pressure contact tanks consisting of a series of steel shells welded together, lined internally with cement mortar and surrounded with concrete, were installed at Shortlands, Honor Oak, Streatham and Sundridge. Boiler shells were being converted into high pressure contact tanks at seven other well stations. The replacement of obsolete steam driven plant at Cricklewood and Wilmington was substantially completed and work was proceeding on the remodelling schemes at Hadley Road, Orpington and Stoke Newington (final portion). Boring operations were started on November 7th for a second 36in diameter borehole at Brasted.

Tenders have been provisionally accepted and the approval of starting dates are now awaited for the site work and substructure for the building to house the rotary strainers at Lee Bridge, a concrete contact and balancing tank of 4 m.g. capacity at Kew Bridge (consulting engineers, Messrs. Howard Humphreys and Sons), and a covered concrete reservoir to hold approximately 5 million gallons at Knockholt.



CONSTRUCTION OF CONTACT TANK AT WALTON

Aircraft Research Association, Ltd.

A GROUP of companies in the aircraft industry has registered the Aircraft Research Association, Ltd., the intention of which is to design, build and operate what will be the largest trans-sonic/supersonic wind tunnel in this country for testing scale models of aircraft. The tunnel will require approximately 35,000 h.p. Negotiations are in hand with the Ministry of Supply and other authorities, on the siting of the wind tunnel, the supply of power and other services. It is stated that the project was initiated by the technical board of the Society of British Aircraft Constructors, which reported that the progress of British aircraft design and development demanded provision of a large wind tunnel capable of operating at speeds just below and higher than the speed of sound, and available at all times for use by the industry. The companies concerned include most of this country's leading airframe and engine manufacturers. The registered offices of the new company are at 32, Savile Row, London, W.1.

PROTECTIVE ALUMINIUM PAINT.—The United Paint Company, Ltd., has introduced a new bituminous aluminium paint, known as "Unitas," one coat of which is stated to protect against corrosion and at the same time give a high degree of light reflection and heat insulation. It consists of an aluminium paste in a high grade medium based upon asphaltic bitumen, and it can be applied by brushing or spraying. The paint gives a durable bitumen coating to protect metallic surfaces from corrosion, with a top sheath of aluminium. It can be applied to all kinds of surfaces and will cover tar, creosote and bitumen without "bleeding."

Plough Shares

At a general meeting of the Institution of British Agricultural Engineers, which was held in London on January 22nd, a paper entitled "Plough Shares, Types, Designs and Construction," was presented by Mr. David Ransome, M.I.Mech.E. In the course of it, Mr. Ransome said that the modern plough share was the result of years of development by trial and error methods. Thousands of years ago it started as a pointed piece of wood, which had more of a ridging than a ploughing action. In due course the wood point was replaced by a forged iron point, which eventually became very similar to a modern ridging share. This form of share was still used in the Middle East on a plough frame much the same as was used in Biblical times. It was interesting to note that the method of fixing this share to the nose of the wooden plough was a socket arrangement almost identical with that used on certain modern ploughs. Eventually the ridging share, which shed the soil either side of the plough, lost one side and became similar to the modern plough share, which had been in existence for the past 200 years or more.

Up to the end of the eighteenth century plough shares were all wrought iron. In 1785 Robert Ransome was granted a patent for making cast iron shares, which also included a process for tempering them with the aid of salt water. This development obviously enabled cheaper shares to be produced and provided not only a better article but improvement in design owing to the shapes into which iron could be cast, which were not possible in a forged article. This was the first step of any real note in the development of the plough share. In 1803 the same Robert Ransome was granted a further patent for chilling the underside of cast iron shares. Thus was overcome the problem of heavy wear, which up to then had existed in both wrought iron and cast iron shares. Not only was the wear problem overcome, but as the patent covered self-sharpening, the problem of bluntness was also solved. On the Continent steel shares had by and large been adhered to, mostly of the slab form, but it was from America that the steel landside share of the kind so extensively used to-day had emanated.

The paper then outlined the three basic designs of plough share in use to-day, namely, slab, socket and landside. The slab share, whether cast or forged, Mr. Ransome said, was the simplest and cheapest form of share. It was essentially a more or less flat slab of material, though the "better versions" were thickened up somewhat on the landside edge. The socket share was so called because of its socket-like arrangement for fixing to the plough frame or skife. Mr. Ransome considered the landside share to be the strongest of the three designs, whether as a casting or a forging. It was similar to the better designs of slab share, but had a landside consisting of a wedge of metal, which started from the point and, increasing in depth, stretched towards the back side of the share.

Mr. Ransome next mentioned the requirements of a plough share as being ability to keep sharp, ability to retain "pitch" and "land," high resistance to abrasion, strength to withstand shock and breakage and ability to clean in sticky soil. Special attention was drawn to sharpness, "pitch" and "land," it being pointed out in the paper that the sharpness of a share had a great bearing upon the tractive power consumed, a factor which emphasised the need for self-sharpening properties. Moreover, the life of a share, breakage apart, was just so long as it retained its "pitch" and "land" to a sufficient degree to enable it to penetrate the soil and to keep the plough in its work. Plough shares, the paper explained, were made as castings or forgings, the materials used being, for castings, grey iron, chilled iron, malleable iron, carbon steel or manganese steel, and, for forgings, mild steel, carbon steel (0·4 to 0·8 per cent), three-ply steel, manganese steel, or a combination of two or more of those materials. But it was impossible to lay down any hard and fast rules for the best materials to use in a plough share, although there were some general rules.

It was commonly thought, the paper stated, that steel and in particular hardened steel, was the best material for resistance to abrasion; and there was an impression that the best of all steels was manganese steel. But resistance to abrasion was not proportional to hardness only, since the Brinell hardness of chilled iron was only about 450 to 550 and of white iron 500 to 600, whereas that of hardened steel might be as much as 800 V.P.N. or more. Nevertheless, it was probably true to say that the resistance of any particular material to abrasion was proportional to its hardness. Although that might be true, it also seemed that the resistance to wear of a steel was not directly proportional to its hardness. Experience seemed to indicate that to double the life, more than double the hardness was required. Neither white iron nor glass-hard steel could be used for shares as they were both too brittle. Hardened manganese steel had about the same resistance at the same hardness, as straight carbon steel, but where the abrasion was due to the presence of stones and rocks, and there was more of a hammer and gouging action, the work-hardening properties of manganese steel would usually cause it to triumph over chilled shares and steel shares of whatever hardness. Apart from this usage, Mr. Ransome considered, there was no particular advantage in using such an expensive material.

Nearly all steel landside shares and some slab shares were suitably hardened, or hardened and tempered, on their points for a distance of 3in to 5in back from the point, the object being to get the maximum hardness in order to resist abrasion, compatible with adequate strength.

After a reference to the cleaning ability of a plough share, which, Mr. Ransome claimed, was dependent mainly on the share's ability to take a high polish and retain it, the paper dealt with the subject of self-sharpening. It was stated that many attempts had been made to produce a self-sharpening steel share, but so far with only very slight success. Self-sharpening depended upon securing those conditions which allowed of the wearing away of the upper surface of the share faster than the underside and the outer surface of the landside. With a cast iron share this was obtainable by cooling very rapidly or chilling, which treatment would penetrate to any desired depth into the iron according to the analysis of the grey iron used. Although that could be done to a certain extent with steel, the difference in hardness and the depth of the hardened surface were insufficient to provide anything more than a very slight self-sharpening effect.

Finally, Mr. Ransome commented on the research work which, he said, was going on continuously in this country and abroad, in an endeavour to produce better or cheaper plough shares. One aspect of that work was the search for a material which could be deposited on the underside and landside of a steel share to increase its life and to secure self-sharpening features. In another direction an endeavour to cut out the costly equipment necessary for producing chilled self-sharpening shares was showing promising results, although it was questionable whether it would ultimately prove economical.

But despite all the research and experimental work which had been done by individual manufacturers over a period of very many years, nothing very startling had resulted. The most that could be said was that there had been a slight improvement in methods of manufacture and quality of steel used in forged and fabricated shares.

Progress in the improvement of share life was necessarily very slow as it was apparent that it was largely a matter for the metallurgists or scientists first to produce some new kind of material or alloy capable of application to the manufacture of shares—such, for instance, as a cast iron which could be chilled but which had the strength and shock resistance of a 40 carbon steel; or a steel which could be adequately differentially hardened, the hardened surface of which had a resistance to abrasion equal to that of chilled iron; or an inexpensive sintered carbide or other material possessing considerably greater resistance to abrasion than hardened steel, at the same time being easy to deposit and ductile rather than brittle. No doubt some such materials as these would one day be discovered, but so far all the discoveries of the last thirty years or so, Mr. Ransome asserted, had failed to prove to be the answer to the problems related to the securing of better or cheaper shares.

Some Civil Engineering Works in Iran

INTERNATIONAL tension has not prevented substantial progress being achieved during the past year on a number of civil engineering projects in Iran with which British engineers are associated.

The largest of these projects is the water supply system of Tehran, comprising a diversion weir on the River Karaj; intake works and settling tanks; nearly 22 miles of 40in diameter spun bitumen lined steel pipe-line; over 5 miles of masonry and concrete aqueduct; water-treatment, pumping and generating plant; six groups of reinforced concrete storage reservoirs having an initial capacity of 57 and an ultimate capacity of 81½ million gallons; and a distribution system comprising over 300 miles of steel and cast iron pipe varying in diameter from 4in to 46in. All the steel pipes, valves and fittings, and almost 50 per cent of the cast iron pipes are being supplied from the United Kingdom, and the bulk of this material is already in Tehran.

Contracts for the construction of the whole work, with the exception of the treatment plant and certain ancillary buildings, have already been placed with local contractors, who, in spite of lack of previous experience and shortage of suitable plant, have proved themselves capable of making steady progress. Some 50 miles of pipes have been laid in the streets of Tehran since pipe-laying started in February, 1951. British contractors involved in supplying the various materials for the project are the Stanton Ironworks Company, Ltd., Stewarts and Lloyds, Ltd., the South Durham Steel and Iron Company, Ltd., Horseley Bridge and Thomas Piggott, Ltd., and Glenfield and Kennedy, Ltd.

The water supply system of Shiraz is now almost complete. Underground water in an alluvial valley between limestone mountains has been tapped by ten 12in diameter bore-holes of an average depth of 275ft, and pumped to a treatment plant. Pumping has shown each bore-hole to be capable of producing over 20,000 gallons per hour at a steady draw-down level.

After treatment, which is intended to reduce the hardness to a reasonable amount, the water is raised by pumps to two storage reservoirs. These reservoirs have an initial capacity of 1,800,000 gallons, with provision for doubling in size. They deliver a gravity supply into about 75 miles of distribution mains, which are of cast iron in the new city, and of galvanised steel in the narrow winding lanes of the old city, where pipe laying has been rendered especially difficult by the many underground passages just below surface level connecting dwellings on either side of the alley ways.

The waterworks has its own source of power—a diesel generating plant. The numerous British contractors involved in supplying the scheme include the Paterson Engineering Company, Ltd., Stanton Ironworks Company, Ltd., J. Blakeborough and Sons, Ltd., and Worthington-Simpson, Ltd.

In Isfahan, a thermal power station is nearing completion. The five oil-fired boilers of this station are each capable of providing 30,000 lb of steam at 275 lb per square inch, to supply four turbo-alternators, each of 3MW capacity. The station is notable for the fact that it is the largest industrial project of its kind yet undertaken by private enterprise in Iran. The

British contractors involved include Yarrow and Co., Ltd., Metropolitan-Vickers Electrical and Export Company, Ltd., English Electric Company, Ltd., Redpath Brown and Co., Ltd., United Filter and Engineering, Ltd., and the Staveley Chemical and Iron Company, Ltd.

About 100 miles to the west of Isfahan at an altitude of about 6500ft, and in mountainous tribal country, a diversion dam and tunnel are under construction linking the upper reaches of the Karun (Kuhrang) and the Zayandeh Rud. Considerable headway with this work has been been made during the past year under the most difficult conditions. A concrete-lined tunnel some 9200ft in length is being driven through a bewildering assortment of contorted rock formations, and of the whole length just over two-thirds has been driven and a considerable proportion lined.

Progress from the outfall end has been seriously delayed, however, by the ingress of water under high pressure and efforts to get this under control have not yet proved successful. From December to April or May the site is completely isolated, and often buried under many feet of snow, but, nevertheless, tunnelling operations on a reduced scale continued throughout last winter. The melting snow produces flood discharges in the Kuhrang River during the spring and early summer, and further reduces the working season on the diversion dam.

The consulting engineers responsible for the installations in the Isfahan power station are Messrs. Merz and McLellan; for the civil engineering part of the project, as well as for the three other schemes described in this article, the consulting engineers are Sir Alexander Gibb and Partners.

REVETMENT AT FFRITH BEACH

Ffrith Beach Sea Defence Works

A COAST protection scheme, work on which has been in progress since the middle of 1950, is at present approaching completion at Ffrith Beach on the coast of North Wales at Prestatyn, near the estuary of the River Dee. The works involved consist of a stone revetment for the protection of the foreshore, together with a series of timber groynes extending from the revetment towards low water. The beach at Prestatyn is mainly of fine sand and is comparatively flat, extending back in places to sandy dunes about 40ft high forming the shore line. The coast here faces north-west towards the Irish Sea and is unprotected from winds and tides by headlands or islands. In recent years the erosion of the sand dunes has reached serious proportions, and there was a risk of the sea breaking through the dunes and flooding the adjacent land.

The main protection against the sea is provided by a revetment of an overall length of some 3700ft running parallel to the shore line from the Rhyl-Prestatyn boundary eastwards towards Prestatyn. The revetment, which is shown in the accompanying illustration, consists of a line of reinforced concrete piles 12in square by 12ft long, driven into the beach at 5ft centres and fitted with a waling and planking of specially impregnated elm. This construction forms the root of an embankment of rubble stone, the surface of which was rough pitched with hand-packed stones, selected for their weight and flatness. In front of the revetment the beach was excavated and filled with rubble with a pitched slope to form a protective toe to the embankment. The top of the wall was brought up to the same level as the promenade of the adjoining Rhyl sea wall. At the eastern end of the works a short approach road gives access to the beach.

The other major part of the permanent works was the construction of twelve timber groynes, each about 700ft long. They consist of Australian hardwood piles, 9in square by 18ft long, driven into the beach at 5ft centres, to which are fitted either elm or Australian hardwood waling and planking. Every second pile is braced to a similar anchor pile 12ft long, by hardwood struts. The shore end of each groyne is buried in the rubble of the embankment.

The stone for the rubble filling was obtained from the Manor Hill Quarry, Prestatyn, which is situated about 2¼ miles from the site, and the quarrying and transporting of the 33,000 cubic yards of stone required was a major item of work. A second large item was the supply of some 50,000 cubic feet of hardwood timber, much of which had to be imported from Australia.

The works at Ffrith Beach are now substantially complete, except for the construction of fascines to help stabilise the sand dunes. The consulting engineers are Sir William Halcrow and Partners, and the main contractors Holloway Brothers (London), Ltd.

Technical Reports

The Condensation of Water on Refrigerated Surfaces. Food Investigation Special Report No. 54. By J. K. Hardy, K. C. Hales and G. Mann. His Majesty's Stationery Office. Price 1s. 6d.—An important factor in the storage and transport of food is the loss of weight caused by evaporation and the problem in the storage of perishable foods is to control this water loss. Under equilibrium conditions the weight of evaporation is equal to the rate of moisture condensation on the space cooling surfaces. If the surfaces are maintained at a temperature below freezing point, frost accumulates and insulates the pipes thermally and also changes the geometrical arrangement of the cooler causing a deterioration in cooler performance. Part I of the report deals with the general theoretical considerations of the problem. The analogy between heat transfer and surface friction may be extended to cover the transfer of matter by diffusion, and the validity of the method of analysis has been tested by experiments, both on a single wetted plate and on banks of pipes, as described in Parts 2 and 3 of the report. The equality in rates of diffusion of heat and water vapour is shown by the similarity in the profiles of distribution in the boundary layer at different stations along a flat plate. Regarding banked pipes, measurements were made of the rate of heat transfer and resistance to air flow with the pipes dry and this provided the basic data required to analyse the performance when the pipes were wet. Other experiments included condensation of water vapour in wet pipes and the frosting of the pipe banks was studied. The results showed the falling off in overall heat conductance and increase in resistance to air flow with increasing frosting of the cooler surfaces. The report includes an appendix analysing the conditions and giving equations for the calculation of the quantity of air flow through and by-passing a bank of frosted pipes. Another appendix shows how the results may be applied in practice to predict the performance of a piped bank cooler operating under frosting conditions.

French Engineering News

(From our French Correspondent)

French Deputies have asked the Government to hand back to private enterprise those mines which the French Coal Board has closed as being uneconomic, as it is considered that private enterprise could probably work them. The Minister of Commerce and Industry has refused. He pointed out in answer to a question that the number of mines closed accounted for 3500 tons of coal per day produced by 5300 miners. This he considered was an uneconomic use of manpower and all the miners concerned were now working at rich coal faces, whereas the closed mines were, in fact, almost worked out.

* * *

Electricité de France is to introduce a new payments method which, it is expected, will save money for both the company and users. Consumers whose bills come to over 50,000 francs per year will be invited to open a bank account amounting to that sum with the E.D.F. They will receive 4 per cent per annum interest and the E.D.F. will draw from the account the sum necessary to pay for the consumption of electricity.

Smaller consumers will be invited to purchase electricity coupons for 980 francs which will be accepted by the E.D.F. for every 1000 francs of electricity consumed.

It is estimated that this method will obviate the necessity of borrowing from the banks at certain periods of the year at a far higher interest.

* * *

The French Government has announced the planning of a new five years' re-equipment and modernisation programme which will be known as the Second Monnet Plan.

The terms of the order are that modernisation of equipment is to be planned within the framework of, and to meet, the new unified European economic structure.

The first Monnet Plan is still not completed. It is reported that 64 per cent of the coal mining plan has been finished, 68 per cent of the steel plan, 91 per cent of the liquid fuel plan, 87 per cent for cement, 80 per cent of the agricultural equipment plan, and 87 per cent of the railway plan. Gas, coke and the chemical industries are far behind. The original Monnet Plan will, it is stated, be completed regardless of the new programme which is now being drawn up, and which is expected to be ready for examination by the Government in June, 1952.

* * *

The steel position in France is said to be a little easier, although it is far from being normal. Further, the methods employed to ease the situation have many drawbacks. For example, the import of coke from the United States has had a very serious effect upon the price of steel. The Government is hoping to overcome this, and has directed investments towards the construction of new coking plants, but this is a long-term policy.

Owing to more efficient collection of scrap there has been a big improvement in the production of Martin steel, but the demand is constantly increasing and this type of steel is still in very short supply.

The rolling mills have sufficient orders to keep them going for at least one year, but the position is not satisfactory as many mills had important export trade which has been drastically cut at the request of the Government. The mills concerned wish to start taking orders for 1953, particularly from abroad, but the problem of supply remains.

It is understood here that the steel industry will be developed over a long period in order to meet demand, and although more capital will be invested, particularly for the production of sheet steel, the problem of raw materials and fuel supplies is not yet settled.

* * *

French railways has announced that at the moment they have 800 railcars, and that 205 others have been ordered. It is proposed to order another sixty-five during the course of this year, and when all are delivered the S.N.C.F. should have about 1070 of these vehicles in service on about 6500km of line.

Industrial and Labour Notes

F.B.I. Representations on the Budget

Following its customary practice, the Federation of British Industries has submitted to the Chancellor of the Exchequer a memorandum setting out its views on taxation problems to be considered in relation to this year's Budget. Dealing with the demands of re-armament, the memorandum says that, in the immediate future, the dislocation of changing a substantial part of our productive effort from peace to defence will actually tend to reduce productivity, and that in the coming fiscal year the greater contribution to the defence programme must come from cuts in other forms of expenditure. A substantial part of the cuts, it is added, must fall upon capital expenditure.

The memorandum goes on to point out that private industrial capital expenditure represents only about one-fifth of the country's total capital expenditure, but is in some ways the most important element of all. Unless the capital equipment of industry can be maintained, the F.B.I. says, productivity will fall, ability to maintain exports will decline, and the country will sink into still more serious economic difficulties involving a further reduction in the standard of living. The need, it is urged, is not merely to maintain capital equipment, but to modernise it and to increase the ratio of machine power per worker. The Federation's hope is that the Government, faced with the unpleasant task of deciding how the cuts are to be applied, will not allow the pressing exigencies of the immediate situation to mask industry's long-term needs. The pressure to increase the export of capital goods is obviously considerable, the memorandum observes, but the short-term advantage of that course will be dearly bought at the cost of jeopardising the efficiency of British industry.

On the subject of industrial capital formation the Federation says that, from a sample inquiry which it made some months ago, it was found that by the end of 1949 post-war capital expenditure had hardly done more than make good the deficiencies of the war period and that there was less real capital per worker than in pre-war days. That, the F.B.I. comments, is a serious matter when considering the efficiency of British industry and its productivity in competition with industries of other countries, such as the U.S.A., where there have been no corresponding handicaps. There can be no doubt that the excessive weight of taxation upon British industry over several decades is beginning to have its effect upon our competitive power.

Another point emphasised in the memorandum is that the extremely high rate of tax on the individual is weakening the spirit of enterprise and the will to work. There are cases, exceptional perhaps, the Federation says, where labour is not willing to take advantage of the opportunities for greater output which capital expenditure on new mechanical devices renders possible. At the other end of the income scale the extremely high rates of income tax and surtax levied upon the salaries of executives in industry reduce their standard of living below that of persons holding comparable positions in practically every other country in the world. As a result, the F.B.I. asserts, there is a tendency for those people who command high salaries to leave the country for employment overseas, with little or no sign of foreigners of similar calibre being willing to accept employment in this country.

The memorandum stresses that the rates of taxation imposed upon British industry are extremely high; but, in addition, as allowances for depreciation and stock replacement are not based upon the cost of replacement, but upon the original cost, "profits" as measured for tax purposes are higher than true profits. As a consequence, the effective rates of tax are even higher than those that appear on the statute book. In the view of the Federation, this problem of making adequate tax allowance for the replacement of assets is of the highest importance and is one which should be dealt with in the forthcoming Finance Bill.

Women's Wages in the Engineering Industry

The Industrial Disputes Tribunal has made an award by which women workers, aged eighteen and over, in the engineering industry will receive a wage increase of 10s. 1d. a week. The new rates are to be made retrospective to the first pay week after November 23rd last, when men in the industry received an increase of 11s. a week. It has been stated that the unions concerned in the women's claim had hoped that the increase might be equal to that awarded to the men. The increase now recommended by the Tribunal is just about the same amount as the employers offered. Proportionate wage increases are to be made to girls under eighteen. About 400,000 women and girls are affected by the new rates.

National Joint Advisory Council

On Wednesday of last week the National Joint Advisory Council held its quarterly meeting under the chairmanship of the Minister of Labour, Sir Walter Monckton. The Council consists of representatives of the British Employers' Confederation, the Trades Union Congress and the nationalised industries.

An official statement circulated by the Ministry of Labour after the meeting indicates that the Council gave consideration to a variety of matters concerned with the existing economic and labour situations. The manpower situation for the three months September, October and November, 1951, was reviewed, particular attention being given to statistics on short-time and overtime working. It was stated that short-time working, resulting partly from lack of demand and partly from raw material shortages, had further increased by December. The Council agreed to support measures proposed by the Minister to regulate the supply of labour required in the defence, export and basic industries, including the Notification of Vacancies Order.

The Council also discussed training arrangements in industry and agreed to a proposal that selected industries should be invited to review their training schemes for both young people and adults. In particular, those industries are to be asked to examine their apprenticeship schemes and to consider whether the scope of their training arrangements could be widened; whether the period of training could be shortened and the minimum age of entry into apprenticeship lowered; whether the present upper age limits could either be removed or modified to allow older workers, who had shown themselves potentially suitable, to be accepted as craft apprentices; and whether, given intensive methods, workers could be trained for a wider range of employment. In addition, industries are to be asked to examine their schemes for the selection and training of supervisors, whose importance in the promotion of efficiency is being increasingly recognised.

The Notification of Vacancies Order

The Minister of Labour has made the Notification of Vacancies Order, 1952, which will come into operation on February 25th. With certain exceptions, it will restrict and control the way in which employers may seek to engage any worker, and engage any worker who is between eighteen and sixty-five (if a man), or between eighteen and sixty (if a woman). Where the Order applies, an employer must not engage a worker except by notifying a vacancy to an employment exchange or a scheduled employment agency. Employers can still advertise, but their advertisements must make it plain that applicants for a job must apply to an employment exchange or scheduled agency. A worker not excepted from the Order will only be able to get a job by going to an employment exchange or agency. The Order does not include any "direction" to work, as under the former Control of Engagement Order. The Government's intention is to ensure that all those who want to change their employment and all those who are looking for work are guided into jobs which are not only suitable to them, but are also of importance to the nation.

Cement Prices

The Minister of Works has recently consulted the cement industry on the subject of cement prices, the industry having indicated that the greater costs of coal, power, freight, and other items justified an increase. Representatives of the industry informed the Minister of their desire to keep such an increase to a minimum and to establish a firm price for the coming year which would not be raised unless there were further major increases in costs. The increase in price—which took effect on January 25th—has been fixed at 4s. 6d. a ton for ordinary and rapid-hardening Portland cements. A further adjustment in prices in Northern Ireland to cover the cost of sea transport is being considered.

Steel Consumption

Some details published in the British Iron and Steel Federation's *Monthly Statistical Bulletin* show that, when allowance is made for the difference in population, steel consumption per head is nearly twice as high in the U.S.A. as it is in this country. The British figure, in turn, is nearly twice that for France and between four and five times that for Italy. The discrepancy, it is stated, is a reflection of differences in the degree of industrialisation and in the standard of living between the different countries.

In 1950, the apparent consumption of steel per head of population was as follows:—U.S.A., 1237 ingot pounds; United Kingdom, 628 ingot pounds; Canada, 614 ingot pounds; Australia, 540 ingot pounds; Germany, 469 ingot pounds; France, 332 ingot pounds, and Italy, 137 ingot pounds, the consumption figures for 1938 being 456, 436, 281, 455, 654, 252 and 127 ingot pounds respectively. The *Bulletin* remarks that, although on the average of the two pre-war years the U.S.A. was the heaviest consumer of steel, German consumption exceeded the American level in 1938. After Germany, it is stated, the United Kingdom and Sweden were the largest West European consumers, while Italy was the smallest. In the Dominions, consumption pre-war in Australia was higher than in Canada, while in India it was extremely low.

By 1950, steel consumption per head in all countries except Germany had risen considerably above the pre-war level. The American figure had, in fact, doubled and was far in advance of that of any other country. The rate of increase in Canada was only a little below the rate in the U.S.A., both countries having been favourably placed for the expansion of their steel industries during the war. In Europe, the United Kingdom's steel consumption per head of population in 1950 was the highest by a considerable margin, and showed an advance of 25 per cent compared with pre-war. Consumption per head in Italy remained the lowest in Europe. In the Dominions, steel consumption per head in Australia, which before the war had been above that of Canada, fell below in 1950, owing to the fact that labour and fuel shortages hampered the expansion of domestic output.

It should be borne in mind that the calculations which the British Iron and Steel Federation has included in this survey make no allowance for the redistribution of steel consumption resulting from the export of vehicles, machinery and other goods made of steel from the industrialised countries, such as the United Kingdom and the U.S.A., to the less developed countries, such as India and Australia.

Notes and Memoranda

Rail and Road

ROAD ACCIDENTS.—The Ministry of Transport has stated that, in November, 1951, casualties on the roads of Great Britain totalled 19,052, or 1034 more than in November, 1950. The number of people killed was 563, which was fifty-three more than in November, 1950. The principal increases last November were in accidents to pedestrians and pedal cyclists.

Air and Water

CERTIFICATE OF AIRWORTHINESS FOR THE "COMET."—A notable event in British civil aviation occurred on Tuesday, January 22nd, when the Minister of Civil Aviation handed to the de Havilland Aircraft Company, Ltd., at Hatfield, the Certificate of Airworthiness for the "Comet" aircraft. This signifies that the "Comet" is now officially approved for commercial operation and so becomes the first turbo-jet civil airliner in the world.

Miscellanea

DIESEL ENGINE USERS ASSOCIATION.—At the recent annual general meeting of the Diesel Engine Users Association, Mr. Gerald B. Fox was elected president, Mr. Julian S. Tritton was elected honorary secretary, and Mr. F. A. Greene, honorary treasurer.

"CEMENT IN THE MAKING."—A booklet entitled *Cement in the Making* has recently been published by the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1. It is largely pictorial and outlines the various processes in the manufacture of cement.

A SWARF AIR BLAST GUARD.—The Silvaflame Company, Ltd., of 218A, Monument Road, Birmingham, 16, is now making an air blast nozzle for clearing swarf when drilling, &c., which is fitted with a transparent guard to prevent chips rebounding into the eyes of operators.

INSTITUTE OF METALS.—Dr. C. J. Smithells, Director of Research, the British Aluminium Company, Ltd., has been elected president of the Institute of Metals for the year 1952–1953. Mr. G. L. Bailey, M.Sc., and Dr. S. F. Dorey, M.I.Mech.E., F.R.S., have been elected vice-presidents.

THE LATE MR. R. G. THOMSON.—We have learned with regret of the death of Mr. Robert Greig Thomson, which occurred on January 18th at "Rockholme," Elmete Avenue, Roundhay, Leeds. Mr. Thomson was chairman of Clayton, Son and Co., Ltd., Moor End Works, Hunslet, Leeds.

SWEDEN'S TIMBER EXPORTS.—According to *The Anglo-Swedish Review*, Sweden's export sales of sawn and planed timber totalled 875,000 standards at the end of October last, compared with 714,000 standards for the whole of 1950 and an annual average of 754,000 standards during the five-year period prior to the second world war. Including spars, boxboards and sleepers, the total Swedish timber exports for last year have been estimated at about 900,000 standards as against 800,000 in 1950.

INSTITUTION OF METALLURGISTS.—The Institution of Metallurgists has announced that the next examinations for Licentiateship and Associateship will be held from August 25th to September 2nd next. Candidates in this country must submit their applications for permission to enter before May 1st. Applications from overseas candidates must be submitted by April 1st. The necessary forms can be obtained from the Registrar-Secretary, Institution of Metallurgists, 4, Grosvenor Gardens, London, S.W.1.

BUSINESS EFFICIENCY EXHIBITION.—The thirty-eighth Business Efficiency Exhibition is to open at Bingley Hall, Birmingham, on Tuesday, February 19th, and will continue until Friday, February 29th. About 33,000 square feet of space will be taken up by the display of all kinds of office equipment. The organisers—the Office Appliance and Business Equipment Trades Association, Panton House, Haymarket, London, S.W.1—state that the number of inquiries received indicates a big attendance of buyers from overseas.

TOKEN IMPORTS FROM CANADA AND U.S.A.—It was announced recently that the Token Import Scheme for imports from Canada and the U.S.A. would continue in 1952 "at a reduced level." The Board of Trade now states that the commodities included in the scheme will be the same as for last year, and that imports of those goods will be permitted up to 30 per cent by value of each manufacturer's pre-war trade with the United Kingdom in the item in question. For 1951 the quota was 40 per cent. Importers applying for licences under the scheme must furnish the necessary documents obtained by their overseas suppliers. In the case of Canada these are "token shipment vouchers" issued by the Department of Trade and Commerce, Ottawa, and in the case of U.S.A. "token scrip" issued by the Office of International Trade and Department of Commerce, Washington.

A SURFACE CLEANING MATERIAL.—We are informed by E. R. Howard, Ltd., of Stowmarket, that it has now introduced a new surface cleaning material for the preparation of metal surfaces before recellulosing or repainting. This new product, known as "shim," removes from a previously treated surface all wax, grease, tar and other elements, including silicone-base polishes. After cleaning with this material, the makers state, the surface is quite clean and degreased ready for the application of normal solvents.

THE ILLUMINATING ENGINEERING SOCIETY.—The Illuminating Engineering Society is arranging a summer meeting at Eastbourne from Tuesday to Friday, May 20th to 23rd. The programme includes a reception by the Mayor of Eastbourne, at the Winter Garden, on Tuesday evening, May 20th; a visit to the Glyndebourne Opera House on May 21st, and the president's reception and dinner at the Grand Hotel on May 22nd. On each day of the meeting there will be technical sessions for the presentation and discussion of papers.

MAINTENANCE OF ALUMINIUM ALLOY EQUIPMENT.—The Production Department of the National Coal Board has issued Information Bulletin No. E.G. (51) 10, entitled *Some Notes on the Repair and Maintenance of Aluminium Alloy Equipment*. The Bulletin briefly mentions the properties of aluminium alloys, corrosion and bi-metallic contact, and gives information concerning forming operations. Various paragraphs deal with the methods of joining and of machining the aluminium alloys, while a final section gives advice upon protection against corrosion.

NATIONAL DIPLOMA IN AGRICULTURAL ENGINEERING.—The Institution of British Agricultural Engineers has issued the regulations and syllabus of the examination to be held this year for the National Diploma in the Science and Practice of Agricultural Engineering. The examination will take place at the Essex Institute of Agriculture, Writtle, near Chelmsford, on September 16th, 17th and 18th next. Full particulars are obtainable from the Institution of British Agricultural Engineers, 24, Portland Place, London, W.1. There is also now available—price 2s. 6d.—a pamphlet containing the papers set for last year's examination.

FIRE ENDURANCE OF TIMBER FLOORS.—A booklet entitled *Fire Endurance of Timber Beams and Floors* has recently been published by the D.S.I.R. The traditional timber joist floor with a lath and plaster ceiling has a fire resistance of about thirty minutes when tested according to B.S. 476, but the need for economy in the use of timber has led to the design of lighter sections. It is important to know how this measure will affect the fire-resistance of such structures, and the bulletin summarises the results of a series of fire tests on timber beams. A formula is developed by which the time taken for a beam to collapse may be estimated from its dimensions and the superimposed load; the analysis is extended to predict the time of collapse of floors supported on timber beams. The booklet is published by H.M. Stationery Office at a price of 1s.

DOW PRIZE COMPETITION.—In memory of John Stewart Dow and in virtue of a bequest by him, the Illuminating Engineering Society offers a prize which will be awarded to the winners of a competition intended to encourage collaboration between students of illuminating engineering or those branches of engineering concerned with illumination and students in other fields in which applied lighting plays an important part. While entries from individuals are not excluded, the competition is primarily intended for students working in collaboration. The winning entry will receive a total cash award of £75 and a certificate will be presented to each member of the winning team. Certificates of commendation will be awarded to any other entries of outstanding merit. The subject for this year's competition is the lay-out, artificial lighting and decoration of a ground floor showroom. The competition will be set and judged by a panel of assessors appointed by the Illuminating Engineering Society, in co-operation with the Royal Institute of British Architects and the Institution of Electrical Engineers. Relevant documents with instructions as to the form which entries should take will be available on April 1st. Forms of application may now be obtained from the Secretary of the Illuminating Engineering Society, 32, Victoria Street, London, S.W.1.

Personal and Business

MR. J. V. DANIEL has been elected to the board of Crompton Parkinson, Ltd.

MR. GORDON R. BALL has been appointed to the board of the International Nickel Company of Canada, Ltd.

MR. V. ARMSTRONG has been appointed secretary of Barr, Thomson and Co., Ltd., Netherton Iron Works, Kilmarnock.

MR. H. F. HARDING JONES, A.M.I.C.E., M.Inst.Gas E., has been appointed deputy chairman of the Gas Council.

MR. J. D. SINCLAIR has been appointed deputy district manager in Glasgow of the Dunlop Rubber Company (Scotland), Ltd.

Mr. R. WALKER and Mr. B. P. Hutton have been appointed directors of Marryat and Scott, Ltd., Wellington Works, Hounslow.

MR. W. E. GIBBS, M.I.E.E., has been appointed engineer-in-chief to the South-Eastern Electricity Board in succession to Mr. W. A. Gallon.

THE UNITED STEEL COMPANIES, Ltd., announce the appointment of Mr. E. E. Ingleton as works manager of Yorkshire Engine Company, Ltd., Sheffield.

MR. P. G. BURNETT, 55, Daisy Street, Victoria Park, Cardiff, has been appointed agent in South Wales, for Brooks and Walker, Ltd., Dockhead, London, S.E.1.

BROWN, O'SULLIVAN AND PARTNERS, consulting engineers, have moved to 123, Victoria Street, London, S.W.1 (telephone, Tate Gallery 0266; telegrams, Bronsul, Sowest, London).

SPENCER-BONECOURT, Ltd., 14, Fetter Lane, London, E.C.4, states that Mr. A. E. Watkins and Mr. S. W. Spurr have been elected to the board. Mr. Watkins has been appointed managing director.

MR. R. E. SLADE has been appointed secretary of the Institution of British Agricultural Engineers. The Institution's headquarters remain at 24, Portland Place, London, W.1 (telephone, Langham 3394).

FARVALUBE, Ltd., and its associate company, Denco Engineering Services, Ltd., both of Hereford, inform us that their new factory and office premises in Holmer Road, Hereford, were recently opened.

THE BRITISH TRANSPORT COMMISSION announces that Mr. Matthew Wallace, solicitor to the Commission in Scotland, will retire at the end of March. He will be succeeded by Mr. Alan Cameron Miller, M.A., LL.B.

THE SHELL PETROLEUM COMPANY, Ltd., announces that Mr. E. Le Q. Herbert, B.Sc., F.R.I.C., is now the general manager of the "Shell" Refining and Marketing Company, Ltd., having succeeded Mr J A Oriel, who has retired for reasons of health

MR. K. S. DAVIES, A.M.I.E.E., director of engineering, Murphy Radio, Ltd., has been elected chairman of the Radio Communication and Electronic Engineering Association. Mr. C. G. White, director and general manager of the marine division of Kelvin and Hughes, Ltd., has been elected vice-chairman.

Contracts

PIRELLI-GENERAL CABLE WORKS, Ltd., has received an order to manufacture and install an insulated cable for operation at a higher voltage than that at which any industrial cable in the world is at present operating. The cable, which will be made at the company's Eastleigh Works, Hampshire, will be a 0·4 square inch, single-conductor, oil-filled cable, with sealing ends to form a 750-yard termination for an overhead line in Canada, operating at 301kV, three-phase, with centre point earthed. An order for a similar three-phase termination has been placed with a Canadian cable maker, and this cable will also be of the oil-filled type. The cable will be graded dielectric construction with the lead sheath metal-tape-reinforced and served overall with anti-corrosive finish. The carrying capacity of each cable will be 530A and the three-phase circuit will carry 275MVA. The cable and all accessories have been designed by Pirelli-General in conjunction with Mr. Emanueli of Pirelli, Milan. This cable will be employed in connection with a new melting plant to be built for the Aluminium Company, Ltd., of Canada, at Kitmat, some 400 miles from Vancouver, British Columbia. A new town of 50,000 inhabitants will eventually be built on the site and the aluminium plant will produce 1,000,000,000 lb of refined metal per year.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

AIR ENGINES

663,609. June 11, 1948.—Manufacture of Thermal Regenerators, N. V. Philips Gloeilampenfabrieken, of Emmasingel 29, Eindhoven, Holland.

Thermal regenerators are used in hot gas engines and in refrigerating apparatus operating on the reversed hot gas engine principle. The aim is to obtain a regenerator which occupies little space and giving a high efficiency. The upper drawing shows a perspective view of one form of thermal regenerator filling mass according to the invention. It comprises a cylindrical body of ceramic material through which a large number of very fine channels extend in the vertical direction. A tissue used in the manu-

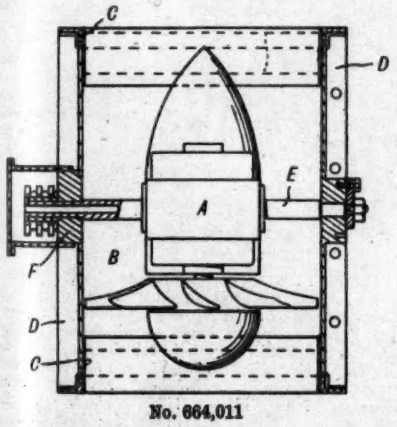
No. 663,609

facture of such a mass comprises a small number of warp wires of metal, and a large number of weft threads of a different metal. This tissue is embedded in a ceramic mass and subsequently rolled, to provide a body shown in the lower view, which indicates the extremities of the threads terminating in the end surface of the mass. After rolling, the mass is heated and during this process the weft threads are melted, thus leaving the channels which open into the end surface of the mass. The metal warp wires, which are of higher melting point, are not affected by the heating process. The diameter of the channels used may be about 0·25mm.—*December* 27, 1951.

BLOWERS AND FANS

664,011. September 19, 1949.—Ventilating Fans, Davidson and Co., Ltd., and Daniel MacFarlane, both of Sirocco Engineering Works, Belfast, Northern Ireland.

According to the invention, the ventilating unit comprises a fan mounted within a fan casing and in which it can be turned through an angle of 180 deg. about an axis transverse of the



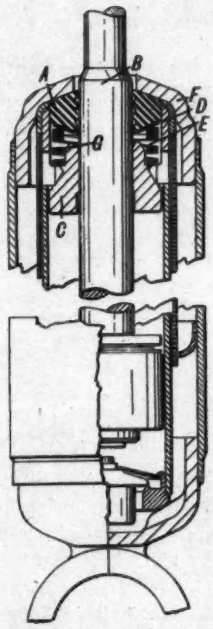
No. 664,011

axis of the fan and casing. The fan motor *A*, together with the motor fairing, fan rotor, and fan rotor fairing assembled as a unit, is mounted within a casing *B*. This has flanged annular ends *C* for bolting to the ducts of a ventilating system. The ends of the fan casing are connected together by two diametrically opposed longitudinal members *D*. Two doors, which complete the casing, are hinged on the longitudinal member and are provided on their free edges with slots engaged by quick-release bolts which are used to lock the doors in the closed position. Two support arms *E* project from the motor at right angles to its axis and are supported in trunnion bearings *F* in the casing members. In use, the fan with the rotor at the bottom, as in the drawing, gives a flow of air in one axial direction. To reverse the flow of air the doors are opened, and when a dowel bolt is disengaged and the locking nut loosened, the fan unit can be rotated through an angle of 180 deg. around the axis of the arms *E*, so that the rotor is at the top. The unit is again locked in position and the doors are closed and locked. In the specification various arrangements for surge and double rotor fans are shown.—*January* 2, 1952.

SHAFT GLANDS AND SEALS

663,600. August 27, 1949.—Sealing Packing for Reciprocative Rods, General Motors Corporation, Grand Boulevard in the City of Detroit, State of Michigan, U.S.A. (*assignees of Mearick Funkhouser and Paul J. Long, of 225, Wisteria Drive, and 333, Shroyer Road, Dayton, Ohio, U.S.A.*).

As shown in the drawing, the packing *A* is ring-shaped with its two outside circular edges chamfered and is applied to the piston-rod *B* of a telescopic hydraulic shock absorber. The rod carries a piston which reciprocates in the cylinder, closed at one end by a head member *C*, in which rod is slidably supported. The head member has an



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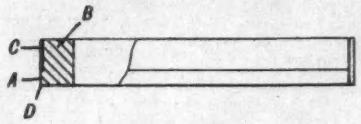
annular extension *D*, upon the outer peripheral edge of which rests the inwardly extending flange of a tubular baffle *E* which surrounds the cylinder for a portion of its length so as to form an annular space around it. A cover cap *F* fits over the end of a tube to form an annular reservoir around the cylinder. One chamfered edge of the packing fits against the cover cap, the other chamfered edge fits against a pressure ring which is engaged by a compression spring *G*, seated upon the head member. The packing is made of resilient material, such as synthetic rubber, which is impervious to and unaffected by the liquids used in the device. The inner cylindrical surface of the packing has alternate annular grooves and lands, which, according to the invention, reduce wear to a minimum. This packing scrapes the liquid off the rod as it moves outwards from the chamber, but permits liquid transfer from groove to groove and finally back into the chamber as the rod moves in the opposite direction. The raking angle of the one land is such that, although it grips the rod with sufficient pressure to scrape off liquid as it moves through the packing in one direction, rolling or peeling movement of the land with the rod is eliminated. The useful life of the packing is thereby appreciably lengthened. The lands do not grip the rod tightly, so that as the rod is moved in the opposite direction any liquid in a groove will be transferred to the next groove adjacent to the chamber. This packing thus prevents liquid passage in one direction and allows it in the opposite direction. The shapes of the alternate grooves and lands are illustrated in the specification.—*December* 27, 1951.

INTERNAL COMBUSTION ENGINES

664,114. July 18, 1949.—Piston Rings, The British Piston Ring Company, Ltd., Holbrook Lane, Coventry, and George Edward Phipps, of the company's address.

The object of the invention is to provide an improved ring which combines the advantages of a chromium-plated and an unplated ring, and in a manner which is capable of easy manufacture. It consists of a plated ring having a narrow unplated land adjacent to one edge only of the ring. As shown in the drawing, the narrow land *A* adjacent



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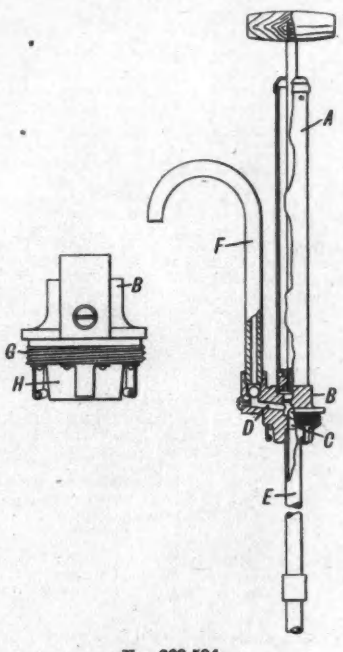
to the edge of the ring *B* is the lower edge when the ring is applied to a piston for a vertical cylinder engine. Around the other portion of the periphery of the ring is formed a shallow groove or step of convenient radial depth, say, 0·002in to 0·005in, to accommodate the chromium deposit *C*. The land is so shaped as to provide a sharp lower corner at *D*. The width of the land can be varied to suit different requirements, but for most purposes a width lying between one-tenth and one-third of the width of the ring is satisfactory. Chromium is deposited over the whole of the outer peripheral surface of the ring, and subsequently is reduced by grinding to expose the land.—*January* 2, 1952.

PUMPS

663,594. August 4, 1949.—Reciprocating Pumps for Oil or other Liquids, Stanley Dewsnap Hill, of Beta Works, Fitzwilliam Street, Sheffield, 1.

This invention relates to pumps for direct attachment to liquid containers such as oil drums, barrels,



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&c. As shown, a pump cylinder contains a hand-operated plunger of usual design with a double-cup washer. The base of the cylinder *A* is threaded into a valve housing *B* formed with an inlet passage *C* and an outlet passage *D* containing non-return ball valves. An inlet pipe *E* and an outlet pipe *F* can be provided in sets for different conditions of operation. The lower portion of the valve housing has an internal screwed adaptor *G* for direct connection into the standard filler-hole threads of large barrels, and a smaller further extension *H* of frusto-conical shape for pressing into the tapered bore of protruding inlets of small drums. To assist the wedging action of the conical adaptor with a drum inlet, three equally spaced spring clips are screwed to the underside of the threads to grip the walls of a protruding inlet. The invention thus provides a pump of simple construction which is not only immediately available for use on containers having different kinds and/or sizes of inlet, but also renders unnecessary any loose parts such as separate adaptors.—*December* 27, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Mon., Feb. 4th.—LEEDS BRANCH: Great Northern Hotel, Wellington Street, Leeds, 1, "Textile Electrification," R. Spence, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, "The High Rupturing Capacity Fuse and its Scope," A. Crinson, 8 p.m.——SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "Electronics in Industry," Mr. Macdonald, 7.30 p.m.

Tues., Feb. 5th.—W. LONDON BRANCH: Windsor Castle Hotel, 134, King Street, Hammersmith, W.6, "Electrical Oils," E. C. Montgomery, 7.30 p.m.

Wed., Feb. 6th.—N. LONDON BRANCH: "Three Jolly Butchers" Hotel, Wood Green, N.22, "Supervisory Remote Control of Electrical Supplies," John F. Fletcher, 8.15 p.m.——YORK BRANCH: Creamery Restaurant, Pavement, York, "Electrical Measuring Instruments and Industrial Metering," J. Collinge, 7.30 p.m.

Thurs., Feb. 7th.—S. LONDON BRANCH: Cafe Royal, North End, Croydon, "General Installation Work with Reference to Large Blocks of Flats," J. W. Quelch, 8 p.m.

Fri., Feb. 8th.—BRISTOL BRANCH: Grand Hotel, Bristol, "Automobile Welding Repairs," A. Gilliard, 7.30 p.m.——CREWE BRANCH: Copeland Arms Hotel, Glebe Street, Stoke, "Industrial Lighting," V. Heydon, 7.30 p.m.——LIVERPOOL BRANCH: Lecture Theatre Service Centre, 9, Whitechapel, Liverpool, lecture and film, "Distinguished Company," 7.30 p.m.

British Institution of Radio Engineers

Thurs., Feb. 7th.—SCOTTISH SECTION: Royal Technical College, Glasgow, "Some Special Oscillograph Techniques," F. M. Bruce, 7 p.m.

Cleveland Institution of Engineers

Mon., Feb. 4th.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The Development of the Wilton Site," R. E. Newell, 6.30 p.m.

Illuminating Engineering Society

To-day, Feb. 1st.—BATH AND BRISTOL CENTRE: S.W. Electricity Board, Colston Avenue, Bristol, "Lighting of the New House of Commons," C. Dykes Brown, 6.15 p.m.

Tues., Feb. 5th.—STOKE-ON-TRENT GROUP: 31, Kingsway, Stoke-on-Trent, "Lighting of Architecture," G. Grenfell Baines, 6 p.m.——LIVERPOOL CENTRE: Merseyside and N. Wales Electricity Board's Service Centre, Whitechapel, Liverpool, "Lighting of an Ocean Terminal," H. S. Allpress, 6 p.m.

Wed., Feb. 6th.—NEWCASTLE CENTRE: Minor Durrant Hall, Oxford Street, Newcastle upon Tyne, "Illumination and Illusion," P. Hartill, 6.15 p.m.

Thurs., Feb. 7th.—NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, "Illumination of a Medium-Size Factory," W. K. Martin, 5.30 p.m.

Fri., Feb. 8th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, "Industrial Lighting," E. H. Norgrove, 6 p.m.

Incorporated Plant Engineers

Tues., Feb. 5th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "The Use of Low-Grade Fuels in Shell Boilers," E. G. Ritchie, 7 p.m.——EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "Consideration of Boilers for Industrial Plant," H. E. Partridge, 7 p.m.

Wed., Feb. 6th.—SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "The Design and Construction of Foundations," Mr. Glover, 7.30 p.m.

Thurs., Feb. 7th.—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, "The Working of a Locomotive Running Shed," J. Blundell, 7.30 p.m.

Institute of Industrial Supervisors

Wed., Feb. 6th.—BRISTOL SECTION: Grand Hotel, Bristol, "Hard Metal," film and discussion, 7.30 p.m.

Thurs., Feb. 7th.—NEWARK SECTION: Welbeck Hotel, Nottingham, "Modern Foremanship," H. R. Harbott, 7.30 p.m.——ROTHERHAM SECTION: Grand Hotel, Sheffield, "Supervision and Management," S. Waugh.——S. WALES AND MONMOUTHSHIRE SECTION: Lines Bros., Merthyr Tydfil, "Management Forum," 7 p.m.

Institute of Metals

Tues., Feb. 5th.—SHEFFIELD LOCAL SECTION: Grand Hotel, Sheffield, "Casting of Billets with Special Reference to Continuous Casting," E. Scheuer, 7 p.m.——S. WALES LOCAL SECTION: University College, Metallurgy Department, Singleton Park, Swansea, "Historical Developments of Tube Manufacture," R. T. Staples, 6.30 p.m.

Thurs., Feb. 7th.—LONDON LOCAL SECTION: 4, Grosvenor Gardens, S.W.1, "Chromium and Chromium-Rich Alloys," A. H. Sully, 7 p.m.

Institute of Road Transport Engineers

Mon., Feb. 4th.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Rear Axles," R. H. Wilson, 7.30 p.m.

Tues., Feb. 5th.—EASTERN GROUP: Marshalls Airport, Cambridge, "Some Factors Influencing the Choice of a Crankcase Lubricating Oil," A. Towle, 7 p.m.

Fri., Feb. 8th.—S. WALES GROUP: S. Wales Institute of Engineers, Park Place, Cardiff, open discussion meeting, 7 p.m.

Institution of Chemical Engineers

Tues., Feb. 5th.—GRADUATES' AND STUDENTS' SECTION: S. WALES CENTRE: University College, Museum Avenue, Cathays Park, Cardiff, "Some Chemical Engineering Problems in the Paper Manufacturing Industry," B. Bienkiewitcz and J. Mardon, 7 p.m.

Thurs., Feb. 7th.—GRADUATES' AND STUDENTS' SECTION: N.W. CENTRE: Queen Hotel, City Road, Chester, "A Review of Liquid-Liquid Extraction," A. Woodwark, 7 p.m.

Institution of Civil Engineers

Tues., Feb. 5th.—Great George Street, Westminster, London, S.W.1, "Some Recent Experience in Composite Pre-Cast and In-Situ Concrete Construction, with Special Reference to Prestressing," F. J. Samuely, 5.30 p.m.

Institution of Electrical Engineers

Mon., Feb. 4th.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Development of Electrical System on the Bristol 'Brabazon I,' Mark I, Aircraft," M. J. Cronin, 6 p.m.

Thurs., Feb. 7th.—Savoy Place, London, W.C.2, "The Economics of Low-Voltage Electricity Supplies to New Housing Estates," F. G. Copland, 5.30 p.m.

Institution of Engineering Inspection

Wed., Feb. 6th.—Chamber of Commerce, 95, New Street, Birmingham, "Control of Quality on Medium and Large-Quantity Engineering Production," J. Loxham, 7.30 p.m.

Institution of Locomotive Engineers

Wed., Feb. 6th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, informal discussion on "Passenger Comfort on Modern Coaching Stock," 5.30 p.m.

Institution of Mechanical Engineers

To-day, Feb. 1st.—Storey's Gate, St. James's Park, London, S.W.1, "Powered Flying Controls: Some Design Considerations," F. J. Bradbury and S. M. Parker, 5.30 p.m.——N.E. BRANCH, GRADUATES' SECTION: Northern Gas Board Showrooms, Grainger Street, Newcastle upon Tyne, "The Engineer's Place in the Atomic Energy Project," T. W. Berrie, 7 p.m.

Mon., Feb. 4th.—N.E. BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, "Ship Research," S. Livingston Smith, 6 p.m.

Tues., Feb. 5th.—GRADUATES' SECTION: Storey's Gate, St. James's Park, S.W.1, "The Performance Testing of Agricultural Tractors and Interpretation of Results," P. H. Southwell, 6.30 p.m.

Wed., Feb. 6th.—MIDLAND BRANCH, GRADUATES' SECTION: College of Technology, Rugby, "The Control of Industrial Processes by Weight," M. C. Hawkings; "Electrical Equipment for Overhead Travelling Cranes," R. Windley, 6.30 p.m.——SCOTTISH BRANCH: University College, Dundee, "Ship Research," S. Livingston Smith, 7.30 p.m.——SOUTHERN BRANCH: Municipal College, Portsmouth, "A New Power Stroboscope for High-Speed Flash Photography," W. D. Chesterman, R. R. Clegg, G. T. Peck, and A. J. Meadowscroft, 7 p.m.

Thurs., Feb. 7th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Design and Manufacture of Heavy Vertical Boring Mills," J. H. Rivers, 6.45 p.m.

Fri., Feb. 8th.—WESTERN BRANCH: Technical College, Brunswick Road, Gloucester, "Industrial Design and its Relation to Machine Design," H. G. Conway, 7 or 7.30 p.m. (to be fixed later).

Institution of Production Engineers

To-day, Feb. 1st.—W. WALES SECTION: Central Library, Alexandra Road, Swansea, "Methods and Relations," J. R. Immer, 7.30 p.m.

Tues., Feb. 5th.—HALIFAX SENIOR AND GRADUATES' SECTION: White Swan Hotel, Halifax, "The Machine Tool Industry," W. J. Morgan, 7.15 p.m.——READING SECTION: Transport Equipment (Thornycroft), Ltd., Worting Road, Basingstoke, "Production of a High-Performance Sports Car," J. Silver, 7.15 p.m.

Wed., Feb. 6th.—NOTTINGHAM SECTION: Victoria Station Hotel, Milton Street, Nottingham, discussion on "The Economic Use of Materials in Production Engineering," 7 p.m.——WOLVERHAMPTON SECTION: Anchor Hotel, Wednesbury, Staffs, "Abrasives," J. G. Cowan, 7 p.m.

Thurs., Feb. 7th.—LONDON SECTION: Royal Empire Society, Northumberland Avenue, W.C.2, "Certain Aspects of Modern Mechanisation of Jobbing and Repetition Foundries," A. F. Beech, 7 p.m.

Fri., Feb. 8th.—EASTERN COUNTIES SECTION: Public Library, Northgate Street, Ipswich, "Electronic Control of Machine Tools and Self-Regulating Systems," R. Parr, 7.30 p.m.

Institution of Sanitary Engineers

Tues., Feb. 5th.—Caxton Hall, Westminster, London, S.W.1, "Sanitation in the British West Indies," C. L. Langshaw, 6 p.m.

Institution of Structural Engineers

Tues., Feb. 5th.—NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The Moving of King Henry VIII's Wine Cellar, Whitehall Gardens," L. Scott White, 6.30 p.m.——NORTHERN IRELAND BRANCH: College of Technology, Belfast, "Some Economies in the Fabrication of Steel Sections," R. Montgomery, 7.30 p.m.

Wed., Feb. 6th.—NORTHERN COUNTIES BRANCH: Neville Hall, Newcastle upon Tyne, "The Moving of King Henry VIII's Wine Cellar, Whitehall Gardens," L. Scott White, 6.30 p.m.

Junior Institution of Engineers

To-day, Feb. 1st.—39, Victoria Street, London, S.W.1, Exhibition of Films, 6.30 p.m.

Mon., Feb. 4th.—N.W. SECTION: Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester, "Impressions of America," Frank Burgess, 7.30 p.m.

Wed., Feb. 6th.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Amateur Telescope Making," R. D. Gifford, 7 p.m.

Fri., Feb. 8th.—39, Victoria Street, London, S.W.1, "Modern Submarine Cables," E. A. Applebee, 6.30 p.m.

Leeds Metallurgical Society

Thurs., Feb. 7th.—The University, Leeds, "The Low Temperature Properties of Metals," D. W. Naylor, 7 p.m.

Liverpool Metallurgical Society

Fri., Feb. 8th.—The University, Brownlow Street, Liverpool, "Some Technical and Economic Problems in the Conservation of Fuel," A. L. Roberts.

Manchester Association of Engineers

Fri., Feb. 8th.—College of Technology, Manchester, annual lecture, F. C. Williams, 6.45 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Fri., Feb. 8th.—Mining Institute, Newcastle upon Tyne, "Fuel Injection Systems for Large Marine Engines," P. Jackson, 6.15 p.m.

Royal Aeronautical Society

Thurs., Feb. 7th.—Institution of Civil Engineers, Great George Street, London, S.W.1, "The Availability and Use of Aeronautical Information," 6 p.m.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, S.W.1.

LANCASHIRE AND CORNISH BOILERS OF RIVETED CONSTRUCTION; HORIZONTAL MULTITUBULAR BOILERS OF RIVETED CONSTRUCTION; VERTICAL CROSS TUBE BOILERS OF RIVETED CONSTRUCTION; VERTICAL MULTITUBULAR BOILERS OF RIVETED CONSTRUCTION; LOCO-TYPE MULTITUBULAR BOILERS OF RIVETED CONSTRUCTION

Nos. 537 : 1951, 609 : 1951, 665 : 1951, 761 : 1951, 931 : 1951. This important series of revised standards for shell boilers of riveted construction has just been issued. The original editions of these standards have been extensively revised. The terms "maximum permissible working pressure" and "safety valve blow-off pressure" in the Factories Act, 1937/1948, have been deleted and replaced by the term "design pressure." These standards deal with materials, construction, workmanship, scantlings, inspection and testing of the boilers. The formulæ in the sections dealing with scantlings give in all cases the minimum scantlings and apply to boilers constructed throughout under competent supervision. Typical methods of attachment of stand-pipes and pads secured by welding alone are given in an appendix to each of these standards. Price 6s. each, post free.

PARALLEL DOWEL PINS (STEEL)

No. 1804 : 1951. This Standard distinguishes between dowel pins, parallel pins and straight pins. Four grades of pin have been included. The grades follow the degree of accuracy of the diameter, the two most accurate being designated as precision ground dowel pins. The range of diameters and lengths for the precision ground dowel pins will cover all the normal requirements of the jig and tool industry. Such pins will be found invaluable for use in many forms of press tools and in numerous types of jigs. Material and limits of tolerance are specified while a table giving the dimensions and grades of pin normally available is included. Price 2s. post free.

GRAPHICAL SYMBOLS FOR GENERAL ELECTRICAL PURPOSES

No. 108 : 1951. This Standard, in its present revised form, has been considerably extended and covers graphical symbols relating mainly to power and lighting applications. It includes general symbols and detailed symbols, relating to generating and converting plant, conductors, machines, rectifiers, transformers, switchgear, resistors, surge diverters, fuses, relays, lamps, electric clocks, traction, and location symbols for installations. Full lists of code letters are also included and among the innovations are a list of "device function numbers" for control equipment and a colour scheme to distinguish voltages. A number of typical diagrams showing the use of the symbols are appended. Price 10s. 6d. post free.